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Fiscal Policy in a Financially and Economically Interconnected World: Essays on Financial Sector Taxation and Regional Public Expenditure

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Fiscal Policy in a Financially and Economically Interconnected World: Essays on Financial Sector Taxation and Regional Public Expenditure

by

Maria Jose Delgado Coelho

A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in Economics in the Graduate Division of the University of California, Berkeley

Committee in charge:
Professor Alan J. Auerbach, Chair
Professor Yuriy Gorodnichenko
Professor Christine A. Parlour
Professor Emmanuel Saez

Summer 2016
Fiscal Policy in a Financially and Economically Interconnected World: Essays on Financial Sector Taxation and Regional Public Expenditure

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by
Maria Jose Delgado Coelho
Abstract

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The increasing degree of financial-macro linkages in advanced economies as demonstrated by the recent Great Recession in the United States and Europe raises new challenges for fiscal policy making, in that it expands the potential impact of both tax and expenditure reforms through uncharted channels. In addition, we are faced with an increasingly globalized world, with substantial spillovers of economic policy between states and countries being driven not only by shifts in the demand for goods and services (as understood in the classic international trade literature), but also by movement of labor and highly mobile capital flows. This interdependence conditions the efficiency of domestic fiscal policy in unprecedented ways not captured by most standard closed economy macroeconomic models or traditional optimal tax theory. This dissertation is motivated by the combination of these two forces and investigates the reform of the financial sector and countercyclical new Keynesian fiscal stimuli as policy responses in the aftermath of the latest financial crisis and recession.

The first chapter analyzes the effect of the introduction of financial transaction taxes in equity markets in France and Italy in 2012 and 2013, respectively, on asset returns, trading volume and market volatility. Using two natural experiments in a difference-in-differences design, I identify bounds on elasticity estimates for three categories of avoidance channels: real substitution away from taxed assets, retiming (anticipation of transaction realizations and portfolio lock-in), and tax arbitrage (cross-platform and financial instrument shifting). I find large responses on all margins, that account for significantly lower revenues than projected. By far the strongest behavioral response comes from high-frequency trading lock-in on regulated exchanges, with a high tax elasticity of this type of turnover in the order of -9.
The results shed light on features of optimal FTT design, suggesting they may be poor instruments for both revenue-raising and Pigouvian objectives.

The second chapter complements the empirical analysis of the first chapter by analyzing the welfare implications of a linear financial transactions tax in a multi-period portfolio selection model with heterogeneous agents. Under certain conditions over the redistribution of government revenues, with no Pigouvian motives, I find such a tax may induce first-order losses due to the distortion of idiosyncratic risk-sharing (an implication which differs importantly from other literature on the role of taxation under uncertainty). A transaction tax induces both a contemporaneous inaction region and intertemporal shifting of transaction realizations. Given a segmented market over multiple trading platforms and the choice of at least two different tax instruments, I develop sufficient statistic formulas that differ from standard optimal commodity tax theory in that they account for untaxed capital accumulation, market structure rents, and uncertain returns. Furthermore, I explicitly consider retiming responses in transaction realizations and tax arbitrage in the form of shifting across trading platforms by allowing investors to choose trading in two different markets, and am able to match such parameters to empirically measured elasticities from my the first chapter, thus informing optimal FTT policy rates. In the case of a linear tax with a single market, the simplest model in this chapter suggests a cash equity transaction tax of 0.67% on the notional value of transactions purely to maximize revenue. A transaction tax induces both a contemporaneous inaction region and intertemporal shifting of transaction realizations.

The third and final chapter deals with more aggregate effects of fiscal policy. It primarily contributes to the open economy local fiscal multiplier literature by estimating regional output and employment responses to federal expenditure shocks in the European Union. Specifically, I use a novel methodology and dataset on fiscal transfers from the European Commission to subnational regions. Mimicking the literature on foreign aid and growth, I use shocks to the supply of federal transfers (European Commission commitments) of structural fund spending by subnational region as instruments for annual realized expenditure in a panel from 2000-2013. By correctly isolating these fiscal shocks, I find significantly larger fiscal multipliers than the existing literature - a large, contemporaneous multiplier of 1.7, which translates into a cumulative multiplier of 4 three years after the shock. Furthermore, using a novel dataset on bilateral trade between EU regions, I find evidence of demand-driven spillovers up to three years after a shock. In addition to direct implications for federal public finance management globally, these results represent an important step in our understanding of the effect of fiscal stimulus and austerity measures in countries undergoing financial and sovereign debt crises.

Overall, this dissertation aims at answering key questions brought about by the
increasing complexity and dynamism of financial and economic interdependence of agents across states and countries. The implications of the results presented here are broad, including the development of comprehensive global financial regulation, the characterization of banking and fiscal unions in the Eurozone, and the incorporation of financial markets into new macroeconomic policy making.
Para ser grande, sê inteiro: nada teu exagera ou exclui.  
Sê todo em cada coisa. Põe quanto és no mínimo que fazes.  
Assim em cada lago a lua toda brilha, porque alta vive.  
- Ricardo Reis
# Contents

<table>
<thead>
<tr>
<th>Contents</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Figures</td>
<td>iv</td>
</tr>
<tr>
<td>List of Tables</td>
<td>vi</td>
</tr>
<tr>
<td>1 Dodging Robin Hood: Responses to France and Italy’s Financial Transaction Taxes</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Natural Experiments</td>
<td>5</td>
</tr>
<tr>
<td>1.3 FTTs as optimal taxes and revenue raising tools</td>
<td>9</td>
</tr>
<tr>
<td>1.4 Policy Implications</td>
<td>26</td>
</tr>
<tr>
<td>1.5 Conclusion and subsequent extensions</td>
<td>29</td>
</tr>
<tr>
<td>2 Dynamic and Cross-Platform Optimal Financial Transaction Taxation</td>
<td>40</td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>40</td>
</tr>
<tr>
<td>2.2 Baseline model</td>
<td>42</td>
</tr>
<tr>
<td>2.3 Cross-platform trading</td>
<td>56</td>
</tr>
<tr>
<td>2.4 Conclusion</td>
<td>72</td>
</tr>
<tr>
<td>3 Fiscal Stimulus in a Monetary Union: Evidence from Eurozone Regions</td>
<td>79</td>
</tr>
<tr>
<td>3.1 Introduction</td>
<td>79</td>
</tr>
<tr>
<td>3.2 Background and data: European Regional Convergence Funds</td>
<td>82</td>
</tr>
<tr>
<td>3.3 Fiscal shock identification strategy</td>
<td>85</td>
</tr>
<tr>
<td>3.4 Panel instrumental variables estimation</td>
<td>86</td>
</tr>
<tr>
<td>3.5 Cross-regional spillover effects</td>
<td>91</td>
</tr>
<tr>
<td>3.6 Conclusion</td>
<td>92</td>
</tr>
</tbody>
</table>
4 Appendices

.1 Appendix for Chapter 1 ............................................. 106
.2 Appendix for Chapter 2 ............................................. 140
.3 Appendix for Chapter 3 ............................................. 175

Bibliography .............................................................. 182
List of Figures

1.1 Timeline of events - France, 2012 ................................................. 7
1.2 Timeline of events - Italy, 2012-2013 .............................................. 8
1.3 France: High market cap Dutch and Belgian vs French turnover .......... 37
1.4 Italy: High market cap Spanish vs Italian turnover .......................... 37
1.5 France: Turnover OTC ................................................................. 38
1.6 Italy: Turnover OTC ................................................................. 38
1.7 Behavioral Elasticities Identification Diagram .................................. 39

2.1 Timeline of investors’ actions in the baseline model ....................... 44
2.2 Risky Asset Demand in $t = 1 \ (\tau_1, \tau_2 > 0)$ ................................ 74
2.3 Deadweight loss for a single linear FTT ........................................ 75
2.4 Laffer curve for single exchange FTT .......................................... 76
2.5 Optimal $\tau^*_EX$ given $\tau^*_OTC$ for different OTC market shares ($\theta_2$) ... 77
2.6 Ratio of on-exchange to OTC tax rates ....................................... 78

3.1 Annual commitments as a share of GDP by NUTS 2 (representative years, Objectives 1+2) ............................................................. 102
3.2 Key explanatory variable and instrumental variable for a representative year ................................................................. 103
3.3 GDP Growth vs Trade-weighted Expenditure Spillover Shock: 2001-2011 104

.1 France: Small vs HMCAP trading volume, 2012 ......................... 134
.2 France: ADR vs domestic treatment group trading volume, 2012 .... 134
.3 France: Intraday Price Volatility (s.d., on exchange) ......................... 135
.4 Italy: Intraday Price Volatility (s.d., on exchange) ......................... 135
.5 France: Undifferenced Log Turnover for Treatment and Control Groups (treatment year) .................................................. 136
.6 Italy: Undifferenced Log Turnover for Treatment and Control Groups (treatment year) .................................................. 136
France: Bloomberg peers vs high market cap French turnover  
France: Undifferenced Log Turnover for Treatment and Alternative Control Group (treatment year)  
Temporary anticipation vs permanent lock-in effect (illustration)  
Italy: High market cap Spanish vs Italian turnover, second-half of 2013 (treatment year)  
Web search intensity for CFD-provider IG Italia around news of a derivative tax postponement  
Intended treatment given reference-period GDP per capita (forcing variable)  
Realized treatment given reference-period GDP per capita (forcing variable)  
Funds committed (Euros per capita) by treatment eligibility: 2000-06 programming period  
Funds committed (for entire programming period) as a share of initial annual GDP: 2000-06 programming period  
Average annual GDP per capita growth by treatment eligibility: 2000-06 programming period, EU-12 only  
High-order polynomial approximation to the conditional expectation of average GDP per capita growth given the forcing variable
List of Tables

1.1 Market Cap by Treatment Groups ( Millions of Euros) - France .......... 32
1.2 Market Cap by Treatment Groups ( Millions of Euros) - Italy .......... 32
1.3 Turnover by Treatment Groups (% of outstanding shares) - France .... 32
1.4 Turnover by Treatment Groups (% of outstanding shares) - Italy .... 32
1.5 Diff-in-Diff French and Italian HMCAP ( vs Dutch & Spanish), Prices .. 33
1.6 Diff-in-Diff French and Italian HMCAP ( vs Dutch & Spanish), Turnover
by Quintiles ...................................................... 34
1.7 Diff-in-Diff French and Italian HMCAP ( vs Dutch & Spanish), Retiming:
Lock-in vs Anticipation ........................................... 35
1.8 Diff-in-Diff French and Italian HMCAP ( vs Dutch & Spanish), OTC .... 36

3.1 Summary Statistics All regions (NUTS 2 level), 2000-2011 .............. 94
3.2 Panel IV - Objective 1 only (NUTS 2 level), 2000-2011 .................. 95
3.3 Panel IV - Objective 1 vs 2 (NUTS 2 level), 2000-2011 .................. 95
3.4 Panel IV - Objective 1 regions: All vs EU-12 (NUTS 2 level), 2000-2011 96
3.5 Panel IV - Objective 1 only (NUTS 2 level), 2000-2011
Unemployment ....................................................... 96
3.6 Panel IV - Objective 1 vs 2 (NUTS 2 level), 2000-2011
Unemployment ....................................................... 97
3.7 Panel IV - Objective 1 regions: All vs EU-12 (NUTS 2 level), 2000-2011
Unemployment ....................................................... 97
3.8 Panel IV - Objective 1 regions (NUTS 2 level), 2000-2011
GDP Components ..................................................... 98
3.9 Panel IV - All regions (NUTS 2 level, all objectives), 2000-2011
Import-weighted fiscal spillovers .................................. 99
3.10 Panel IV - Objective 1 only (NUTS 2 level), 2000-2011
RHS: Spending levels ............................................. 100
3.11 Panel IV - Objective 1 only (NUTS 2 level), 2000-2011
LHS: Percentage output gap ....................................... 100
3.12 Panel IV - Objective 1 only (NUTS 2 level), 2000-2011
   Driscoll-Kraay robust standard errors .......................... 101
   .1 List of treatment and control group firms: France, 2012 ........ 121
   .2 List of treatment and control group firms: France, 2012 (continued) 122
   .3 List of treatment and control group firms: Italy, 2013 ........... 123
   .4 Diff-in-Diff French and Italian Small and HMCAP (On-Exchange) .... 124
   .5 Diff-in-Diff French and Italian HMCAP (Domestic Exchange vs ADRs) 125
   .6 Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), Trades 126
   .7 Sensitivity of Behavioral Elasticity Estimates ........................ 127
   .8 Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), Volatility
      Effect On-Exchange ........................................... 128
   .9 Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), Volatility
      Effect OTC .................................................... 129
   .10 Diff-in-Diff French HMCAP (vs Dutch), Volatility Robustness ....... 130
   .11 Diff-in-Diff French HMCAP (vs Dutch), Prices Robustness .......... 131
   .12 Diff-in-Diff French HMCAP (vs Dutch), Turnover Robustness ....... 131
   .13 Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), Opening
      and Closing Auction Turnover ................................ 132
   .14 Italian Option Volume ......................................... 133
   .15 Regression Discontinuity IV (NUTS 2 level), 2000-2011 ........... 181
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Chapter 1

Dodging Robin Hood: Responses to France and Italy’s Financial Transaction Taxes

1.1 Introduction

The impact of financial sector taxation on financial market activity, corporate investment and aggregate growth is still poorly understood by the public and financial economics literature. Yet, it is an increasingly important area of research from a macroeconomic and fiscal policy standpoint, having risen to the fore of many policy reform debates aiming to reduce systemic risk in the economy and increase the progressivity of the broader tax system. Yet, financial transaction taxes (FTTs) are an old idea. Originally proposed by Keynes (1936) with the aim of mitigating short-term speculation in stock markets and revived by Tobin (1978) to curb speculation in foreign-exchange markets, FTTs are today commonplace in many parts of world, but remain the object of sharp policy controversy, and notoriously understudied in the academic literature. Recent policy reports estimate the introduction of comprehensive financial transaction taxes could induce at least a 0.53% decline in long-run GDP (European Commission (2012)), and as much as 20% of corporate income tax in the European Union is collected from financial institutions, which suggests the presence of sizable fiscal externalities (through losses in corporate tax revenue) when considering tax reforms aimed at this sector. Nonetheless, academic research on the effects of these taxes is limited. Notably, in spite of its historical prevalence across multiple countries and asset types, there is little conclusive evidence on: (i) to what extent FTTs are an optimal tool for raising government revenue and in particular,
CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY’S FINANCIAL TRANSACTION TAXES

whether the elasticities of asset prices and market volume are sufficiently low to grant such an argument; and (ii) what impact (if any) FTTs have on capital market short and long-term volatility and by association welfare of market participants. I address these two questions in this paper.

I use two natural experiments of the introduction of an FTT in fully electronic markets in France and Italy, in 2012 and 2013, respectively, to measure the observable responses of asset prices, turnover and volatility on-exchange and over-the-counter to the tax. To do so, I apply a difference-in-differences extension of an event study design using high-frequency data to each case. I then combine the observed responses in both countries and the variation in tax system design (such as differences in marginal tax rates or exempt asset types) to identify otherwise unobservable underlying behavioral response elasticities of the various core groups of market participants over time.

In contrast to earlier work on this question, I distinguish conceptually between all the core substitution, avoidance and evasion channels involved in the most commonly estimated net aggregate response. The clearly defined and parametrically rich nature of the reforms provides enough variation for a stronger parametric identification of these channels than previously achieved. Given the multiplicity of behavioral channels relevant for this type of taxation, earlier studies provide an incomplete depiction of responses. As shown by Piketty et al. (2014) and more recent behavioral public finance literature, distinguishing between “real” and income shifting responses has first-order implications for optimal tax policy. As an example, if only an insignificant portion of the response of trading activity to transaction taxes is realized through cross-country evasion, then harmonizing tax rates internationally (as is currently being attempted in the Eurozone) should be second-order for optimal taxation. To the best of my knowledge, this paper is the first attempt to quantify the relative magnitudes of different substitution, avoidance and evasion channels available to market participants.

I document two key findings. First, the avoidance response magnitudes of electronic markets to a transaction cost are orders of magnitude larger than those of conventional floor trading markets. Though the implied elasticity estimates relative to transaction costs on regulated exchanges are in line with the upper bound of those found by the previous literature (around -1), the parallel only holds due to the decline in overall transaction costs; in absolute terms (i.e., with respect solely to the change in the marginal tax rate), both turnover and price elasticities are double of existing estimates. Over-the-counter (short-term) and for algorithmic trading, implied elasticities are well above those figures even when computed relative to pre-existing transaction costs, with the lock-in elasticity of the latter group of traders in the order of -9. Together, these effects capture close to 60% of the measured revenue
shortfall relative to original projections following the introduction of the tax in the two countries, with the remainder accounted for by year-on-year growth in trading volumes (the tax base).

Second, real substitution (measured by changes in asset demand) and evasion are of much smaller significance than in the 1980s and 1990s. I argue this is in part due to a change in the digital and regulatory characteristics of modern capital markets, but also due to the large gamut of malleable avoidance opportunities identified in this paper.

These findings suggest FTTs may be poor instruments for government revenue-raising due to the considerable tax base erosion induced. In addition, the weak evidence I detect of an impact of this tax on short-term volatility measures and its mixed targeting of externality-generating agents also challenges the suitability of FTTs as Pigouvian taxes.

Prima facie, the revenue potential from an FTT may seem large given the targeted tax base, but the magnitude of the behavioral response is critical. Earlier empirical literature presents no consensus on the elasticities of financial transactions with respect to transaction costs in general or transaction taxes in particular – most studies referenced by Matheson (2011) and Burman et al. (2015) focus on individual country-specific events of tax reform and very few take into account the responses of different asset markets. Avoidance opportunities also abound for this type of taxes, the most notorious of which are contracts for differences\(^1\), which bypass the need for direct asset trading by cash settling net capital gains. A large lock-in effect could dramatically reduce the fiscal revenues obtained through such a measure. Further, one could expect FTTs to be especially conducive to diversion of financial activity across borders as long as tax measures are not globally implemented, given the exceptionally mobile nature of financial services.

In addition, the effect of FTTs on asset valuation and financial market efficiency is ambiguous. Theoretical models generally predict that higher transaction costs are associated with lower asset prices (since they increase the liquidity premium required by investors to hold them, beyond the capitalization of the costs themselves). The lock-in effect induced reduces overall market liquidity and is likely to jeopardize efficiency in price discovery, which in turn may increase the price impact of trades, heightening short-term price volatility. This is contrary to policy objectives of reducing short-term ("speculative") fluctuations in asset prices by increasing transaction costs.

This paper identifies and measures the magnitude of these responses. However, I

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\(^1\)Bilateral contracts where one party agrees to pay the other the difference between the current value of the asset and its value at a future date.
abstract from the impact of FTTs on capital market efficiency in allocating financial resources to the most fundamentally productive firms in the economy, as well as the corporate cost of capital and firms' financing decisions. I also relegate the discussion of fiscal externalities pertaining to capital gains, dividend or corporate taxes to subsequent research.

There is an established literature evaluating the response of asset holders to reforms in capital gains taxes (Burman and Randolph (1994); Dowd et al. (2012)) and dividend taxes (Chetty and Saez (2005)), in addition to the response of stock compensation realizations for executives following top income tax reforms (Goolsbee (2000)). Likewise, there is an emerging literature examining the response of the housing market to transaction taxes (Fu et al. (2013); Kleven and Best (2015); Kopczuk and Munroe (2015)). This paper contributes to this broad strand of literature by adding to the scarce evaluation of behavioral responses to financial transaction taxes.

Several recent working papers evaluate the introduction of the financial transaction tax in France in 2012 (Becchetti and Ferrari (2013); Colliard and Hoffmann (2016); Meyer et al. (2013); Haferkorn and Zimmermann (2013)), though none disaggregate the behavioral response channels highlighted above. Becchetti and Ferrari (2013) use untaxed French publicly traded stocks (all of those under the market capitalization threshold) as a control group in a difference-in-differences design, while Meyer et al. (2013) and Haferkorn and Zimmermann (2013) use British and German blue chip stocks, respectively, as their control of choice. The first part of this paper is closest methodologically to Colliard and Hoffmann (2016), which looks exclusively at the French case using Dutch stocks as their primary control group in a difference-in-differences estimation design.

However, this paper differs substantially from Colliard and Hoffmann (2016). The latter’s main value-added lies in analyzing changes to low-latency activity through order book data in France, concentrating on descriptive measures of changes in the composition of the trader population and associated market quality. In contrast, this paper identifies policy and welfare-relevant behavioral response margins of representative financial market participants, in line with the public finance literature on capital gains tax avoidance. From an empirical standpoint, I focus both on developments in registered exchanges and in over-the-counter trading platforms, include the analysis of the introduction of a FTT in Italy in 2013, and use additional sets of control groups (including foreign depositary receipts) for both country cases. The key contribution of this paper lies precisely in the use of the cross-country variation in policy design to discern between alternative behavioral responses. In turn, as I will...

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2Defined as “strategies that respond to market events in the millisecond environment” (Hasbrouck and Saar (2013)).
allude to in section 1.4, the distinction between behavioral responses is essential for optimal taxation design - in particular, to determine the marginal tax wedges across asset types and trading platforms necessary to maximize government revenues, while minimizing distortionary deadweight loss.

This paper thus sets itself apart from the previous literature by bridging finance studies on transaction costs and the broader applied behavioral public finance approach, traditionally focused on either labor and corporate income or other types of capital income taxation.

Following a background review of the two case studies I am focusing on for empirical estimation in section 1.2, the remainder of the paper focuses on the response of cash equity markets to the introduction of a transaction tax. Each section briefly reviews the existing literature and conceptual framework, describes the empirical results, and looks at potentially useful ways of summarizing the responses observed in the data in terms of policy and welfare-relevant parameters of interest. Section 1.3 focuses extensively on prices and turnover, while the online Appendix deals with volatility. The heart of the behavioral response identification is derived in section 1.3. I conclude by drawing some policy implications (section 1.4) and delineating open questions for future research beyond the reach of this paper (section 1.5).

1.2 Natural Experiments

French 2012 FTT reform

The French government imposed a unilateral financial transactions tax on August 1st, 2012, (announced on February 29th) which consisted of a 0.2% levy on the purchase of shares of companies headquartered in France with a market cap of at least €1bn, irrespective of trading location. One hundred and nine firms fell into this category during 2012 and they were clearly identified at the beginning of the year. The initial rate announced was 0.1%, increased by the new government to 0.2% on July 4th via the 2nd Amended Finance Law of 2012). The tax is calculated based on the traded price of a share and must be paid on the first day of the next month by the entity that initiated the transaction. The primary market was exempt, so changes on the capital structure of companies, although a worthwhile subject of subsequent research, should be of second order for the moment. The rate of 0.2% is about average of the range of proposed FTT rates for equity transactions in policy discussions, and is based on the notion that the tax should be of the order of existing

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3Every January 1st of each year a new revised list is made public.
CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY’S FINANCIAL TRANSACTION TAXES

bid-ask spreads (amounting to about 0.24% of share prices for high market cap equity transactions in France) in order to minimize behavioral disruptions\(^4\). In addition, high-frequency trading (program trading with amended or canceled orders exceeding two-thirds of transmitted orders) became subject to a 0.01% tax if trading is carried out in France. The measure was part of a comprehensive fiscal devaluation\(^5\), which involves the raising of VAT and financial income taxes, as well as a cut in payroll taxes aimed at making French firms more competitive by lowering labor costs.

For the purposes of the analysis below, it will be useful to keep in mind the following chronology of events: on January 12th, 2012, brokerages suspended orders for cross-book swaps of French stock into ADRs\(^6\) due to rumors of share transfer duties being extended to sales outside of France; on February 7th the first articles in Les Echos, Le Monde and WSJ detailing the legislative bill to be presented to Council of Ministers were published; on February 27th the National Assembly released a report on the ongoing debate of the bill and Presidential candidate Hollande publicly announced support for the measure, which was ultimately approved by Parliament two days later. On July 4th the FTT rate was increased to 0.2% (2nd Amended Finance Law 2012), coming into effect on August 1st. ADRs came under the scope of the tax only on December 1st. Figure 1.1 depicts the timeline of relevant events.

\(^4\)Another way of thinking about this rule of thumb is that transactions requiring similar resources should be taxed at the same rate (with the tax not exceeding those resources), so that if derivatives are a typically less expensive way of obtaining exposure to the underlying asset, the former should be taxed at a lower rate. Effectively, this is often the case in proposals encompassing taxation of both equity and derivative markets (see European Commission (2013) for a recent example).

\(^5\)FTTs are frequently perceived as taxes on consumption of financial services, especially since the latter are typically exempt from invoice-based VAT. The conceptual question of whether financial services should be taxed as final consumption goods at all (instead of being considered intermediate inputs) is dealt with by Auerbach and Gordon (2002).

\(^6\)One can either source new ADRs (American Depositary Receipts, described further in the online Appendix) by depositing the corresponding domestic shares of the company with the depositary bank that administers the ADR program or, instead, one can obtain existing ADRs in the secondary market. The latter can be achieved either by purchasing the ADRs on a US stock exchange or via purchasing the underlying domestic shares of the company on their primary exchange and then swapping them for ADRs (crossbook swaps). Often these swaps account for the bulk of ADR secondary trading.
CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY’S FINANCIAL TRANSACTION TAXES

Jan 12  Feb 7  Feb 27  July 4  Aug 1  Dec 1
Cross-book swaps into ADRs suspended
Parliament reports on discussion of the bill and approves two days later
FTT rate increased from 0.1% to 0.2%
FTT (0.2%) and HFT (0.01%) implemented – ADRs exempted
ADRs come under tax

Figure 1.1: Timeline of events - France, 2012

Italian 2013 FTT reform

Starting on March 1st, 2013, transactions of shares issued by Italian resident companies with a capitalization equal to or higher than €500 million are to be taxed at a 0.1% base rate if executed on-exchange\textsuperscript{7}, and 0.2% if over-the-counter (OTC)\textsuperscript{8}. Securities representing these shares (ADRs, GDRs\textsuperscript{9}, etc) are also under the scope of the tax. The tax is due by the buying party and as in the French case, dues are calculated based on net transfer of ownership position at the end of each day. The list of exempted companies for 2013 was published by the Italian Ministry of Finance on February 1st, 2013. For 2014 and onwards, it will be published by December 20th of each year. As in France, a high-frequency trading tax at a 0.02% rate was also introduced for algorithmic trading based transactions with a cancellation to completion rate greater than 60%; however, as supported by other empirical evidence (Colliard and Hoffmann (2016)), I contend that the high-frequency tax should be infra-marginal to market participants affected by the cash equities tax, since high-frequency/algorithmic traders typically take advantage of intraday arbitrage opportunities, closing the day flat on the asset - in other words, they do not typically carry overnight changes in stock ownership. Nonetheless, a reduction in high-frequency trading due to this specific smaller marginal tax rate would also impact the evaluation of changes in total turnover, and will thus need to be taken into consideration when disentangling the effect of each tax.

\textsuperscript{7}Formally defined as cash equity transactions concluded in a Regulated Market or Multilateral Trading Facility (MTF).

\textsuperscript{8}Both rates were exceptionally set at 0.12% and 0.22% respectively, for 2013 only.

\textsuperscript{9}Global Depositary Receipts.
CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY’S FINANCIAL TRANSACTION TAXES

The Italian Financial Transaction Tax law was approved on December 24th, 2012, and published in the Italian Official Gazette on December 29th, but articles about the voting of the law were published on December 21st\textsuperscript{10}. Details on payments and reporting rules were published in a decree of the Ministry of Economy and Finance on February 1st, 2013. Since the first major series of press articles covering the legislative proposal in detail were published on October 10th-12th (Ore (2012a,c,b)), 2012, I use that as a second announcement date, in a similar fashion to the event identification strategy used for the French case.

In contrast to the French legislation, the Italian tax policy included a very narrow market maker exemption and ensured equity derivatives were included. Although the tax on derivatives was originally not supposed to come into effect until July 1, 2013 (eventually postponed to September 1), the loophole of trading swaps and contracts for differences (CFDs) was restricted from then on. Exacerbating the cross-platform design for cash equities, contracts executed OTC were subjected to a base rate five times higher than those executed on-exchange. The tax on derivatives is a flat tax ranging from €0.025 to €200 depending on the relevant instruments and with stepwise increases dependent on its notional value. Exemptions to the tax are much more limited under this framework - European pension funds being the main one. Figure 1.2 depicts the timeline of relevant events.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{timeline_italy.png}
\caption{Timeline of events - Italy, 2012-2013}
\end{figure}

\textsuperscript{10}I hence use December 21st as one of the announcement dates for Italy.
1.3 FTTs as optimal taxes and revenue raising tools

Conceptual framework

Official government estimates of expected additional revenue accruing from the introduction of a FTT are non-negligible, all the more the broader the range of instruments included under the scope of the tax. With the introduction of the new tax regime, €500 million (0.2% of total government revenue) was expected for 2013 alone in France, and €1 billion for the second half of 2013 in Italy. Yet, most estimates rely on static estimations of tax bases, assuming no behavioral response of financial market participants (avoidance, evasion, participation decline, etc). In addition, there have been few empirical studies in the past that have been able to provide us with well identified elasticity estimates to the introduction of a FTT. High asset valuation and turnover elasticities would undermine the optimality of these types of taxes for revenue purposes. Section discusses the importance of a conceptual framework distinguishing among different behavioral response margins for optimal policy evaluation.

Empirical Literature Review

Perhaps the most widely cited empirical study that attempts to estimate price and turnover elasticities to a FTT is the analysis by Umlauf (1993) of the introduction of a 1% tax on equity trades in Sweden in 1986. Using an event study framework, Umlauf describes a 60% fall in trading in the Stockholm exchange following the reform, with trading activity in the affected companies shifting to London. Furthermore, he finds a 5.3% decline in market value subsequent to the announcement of the tax. Other studies (Hu (1998); Schwert and Seguin (1993); Bond et al. (2004); Oxera (2007)) empirically estimate a range of turnover elasticities between -0.5 and -1.7 and asset value elasticities in the order of -0.15 and -0.4 (calculated relative to total transaction costs\(^1\)). In addition, other papers note the existence of liquidity clienteles (Amihud et al. (2005)), which suggest that FTTs are capitalized more heavily into the prices of assets with high turnover.

\(^1\)Transaction costs are defined as the sum of bid-ask spreads, brokerage fees and security transaction taxes, equaling approximately 0.75% of the security value (0.2% in the case of high-frequency traders and derivative transactions). Other studies (Hawkins and McCrae (2002)) use figures between 1-3% for average cash equity transaction costs on exchange, but industry surveys have shown these to have declined substantially over the last two decades.
Empirical Estimation

I am using the unilateral French reform in 2012 and the Italian reform in 2013 as natural experiments to test several theoretical predictions mentioned above. In particular, I use a difference-in-differences augmented event study based on CAPM to estimate the value and turnover elasticity (subsequently split into four behavioral elasticities as summarized in Figure 1.7) of stocks to the tax rate as an increase in proportional transaction costs. I am exploiting within-asset market cross-border variation by choosing comparable high market cap companies. I use daily (and for some volatility measures intra-day) data from Bloomberg. The core regression of interest for asset prices is the following:

\[ r_{igt} = \alpha_{ig} + \beta_{igt} r_{mt} + \gamma_{igt} D_{gt} + \eta_g + \delta_t + \epsilon_{igt} \]

where \( r_{igt} \) is the price return on security \( i \) of group \( g \) on date \( t \), \( r_{mt} \) is the market return, and \( \gamma_{igt} \) measures the abnormal return caused by the event affecting group \( g \) for asset \( i \) (treatment effect of event). Including additional standard control variables for company size and book-to-market ratio (Fama and French (1993)) to this specification does not alter the results, as attested in the online Appendix. For robustness I also re-estimate the same specifications using the return of blue-chip market indexes in Europe and France as the market benchmark instead (in particular, FTSEurofirst 300 and SBF250). Insofar as we can think of these indexes as "risk-free", the firm-specific daily differential should then correspond to the conventional definition of excess return. Notice that since asset prices are forward-looking, the event dates of interest for the estimation of asset valuation effects are the announcement dates of the tax (as soon as public information can be measured), rather than the actual policy implementation dates.

I use an analogous specification for the triple difference in differences analysis of turnover elasticities (the differencing across years is necessary to extract seasonality effects), where I first difference the last three weeks of the implementation month and pre-implementation month (August versus July, and March versus February, respectively), then the implementation year versus the previous year (2012 versus 2011, and 2013 versus 2012, respectively) and finally treatment versus control groups:

\[ \ln T_{igt} = \alpha + \eta_g + \delta_0 \text{Month} + \delta_1 \text{Year} + \beta_0 \text{Month} \cdot \text{Group} + \beta_1 \text{Month} \cdot \text{Year} + \beta_2 \text{Year} \cdot \text{Group} + \beta_3 \text{Month} \cdot \text{Year} \cdot \text{Group} + \epsilon_{igt} \]

Turnover is defined as total daily transaction volumes (number of shares traded) over the total number of shares outstanding excluding insider ownership. The identifying restrictions for the validity of the specifications above are twofold. First,
CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY'S FINANCIAL TRANSACTION TAXES

conditional on covariates, the average values for treated and controls would have followed parallel paths in the absence of treatment. This is arguably a realistic restriction within the horizon of event study for daily data, but it is less clear when looking at long-run turnover effects. Second, it is critical that no other significant news affected the spreads of interest on selected event days; special care is warranted here for example for earnings announcements causing outliers which can bias the estimates. Note that for turnover the event dates of interest are the implementation dates of the tax; conditional on continuing to invest in the same pool of companies, incentives to alter trading behavior only kick in once the tax actual has some bite. As I discuss in section 1.3, this requires that portfolio substitution towards untaxed assets happen between the announcement and implementation dates, leaving only potential avoidance and evasion post-implementation.

The treatment groups are stocks traded on the Paris and Milan stock exchanges, respectively. I implicitly abstract from trading on non-domestic exchanges, as well as multilateral trading facilities. However, according to studies covering MTFs under the French event study (Haferkorn and Zimmermann (2013)), I do not expect this omission to qualitatively alter the results. All data are taken from Bloomberg.

On-exchange

The key control group used to derive the baseline estimates in this paper are Dutch and Belgian (Spanish in Italy's case) companies above the same respective high market cap thresholds. Like their French counterparts, Dutch and Belgian stocks are also traded on Euronext, hence a priori having a similar group of financial customers and traders involved. The control group alone in this case amounts to 59 companies, against 109 in the treatment group12. Belgium has had a transaction tax in place for most of the 20th century, in the order of 0.17%. However, since I am conducting a difference-in-differences analysis in what follows, what matters is that the control group sees no treatment during the period considered empirically - in other words, that only French stocks were subject to a change in transaction taxes. Using only Dutch stocks (which have no FTT in place) does not qualitatively change the results, and the magnitude impact on coefficients of interest is only marginal13. For Italy, the control group of choice is high market cap Spanish companies. In both country cases (France and Italy) the treatment and control groups share similar macroeconomic shocks over the observation period and are broadly comparable in terms of sectoral and firm size distribution. Appendix A includes summary statistics

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12Due to data availability, effectively we have 57 and 108 companies in each group, respectively.
13Results available upon request.
about the market capitalization and turnover distribution of each set of treatment and control groups. These quantiles correspond to those used to restrict subsamples in Table 1.6. Table 1.5 summarizes the results for changes in asset returns. I conduct the same set of regressions using at least two alternative control groups - domestic small market cap companies and ADRs; those exercises are described in the online Appendix.

The implied price elasticity is -0.075 (a 1% decline in relative returns with an expected tax increase of 0.1% on announcement dates). This estimate is orders of magnitude smaller than the decline of asset values implied by a mechanical partial equilibrium model\textsuperscript{14}. The estimates in France may in fact be an upper bound on the elasticity magnitude if the probability of a doubling of the tax rate after the elections that Spring had been priced in. Furthermore, the results are robust to estimating abnormal return using beyond-sample market indexes as a benchmark (such as the FTSEurofirst 300 and SBF250). I also constructed a placebo test for the change in asset returns using the same control and treatment groups for 2005-2006 instead of 2011-2012, with no valuation effect found on the placebo period, which corroborates the robustness of the results above (see the online Appendix). Early announcement dates for Italy (October 2012) show no significant price effect. A plausible explanation is the high count of articles being circulated simultaneously in those days about the EU-11 agreement to go ahead with a Eurozone-wide Tobin tax in 2014 (Ore (2012d)), which would suppress the differential (if any) between Italian and Spanish stock returns. In addition, October 12th, 2012 was a Friday and a national holiday in Spain; although the Madrid stock exchange was open for trading that day, the lack of significant difference in valuation between Italian and Spanish high-market cap companies that day could also be attributable to the abnormal liquidity in the control group around that day. However, estimates of price elasticity are sensitive to the choice of event date, and cumulative abnormal return regressions do not always yield similar results; I am thus cautious about taking these results at face value. In contrast, the turnover estimates described below are much more robust to choice of estimation windows and are patent even from simple plotting of non-transformed data.

Table 1.6 summarizes the overall turnover effect results using the core control groups. Q1-Q5 refer to the 1st through the 5th quintiles for market capitalization within the French and Dutch/Belgian sample, while T1-T5 correspond to the turnover quintiles for the same companies. Similar cross-sectional patterns are found

\textsuperscript{14}In the online Appendix, I characterize the implications for asset valuation of a transaction tax under a basic partial equilibrium model à la Matheson (2011), which would predict a 12% decline in asset values for a tax of the magnitude observed here.
in the Italian case, which I omit for brevity. The -0.27% coefficient for turnover in France is equivalent to a 24% decline (or a -0.9 implied elasticity with respect to an increase in transaction costs). Colliard and Hoffmann (2016) highlight that when looking at a longer two month horizon, the actual drop in relative turnover is closer to 10%, much smaller than that estimated for the first month after the reform. Several plausible reasons, including time-shifting of realizations and changes in reference point perceptions of excessive transaction costs could be behind this phenomenon. Notwithstanding, for most stocks in the upper liquidity quintiles, volumes persist at historically low relative levels after a temporary rebound in September seen in Figure 1.3. In my sample, this permanent lock-in effect is close to 18%, as discussed in more detail in the next paragraph. Similarly to the robustness test for asset prices, I include a placebo estimate for the 2005-2006 period. Furthermore, I run the same test using a completely different control group - a weighted average of the first three Bloomberg peer companies for each stock. As seen in the online Appendix, using this alternative control group suggests the baseline estimates in this study may in fact be conservative, as the measured decline in turnover in the first month using this alternative is even larger, at 41%.

I also present estimates by quintile of market capitalization and liquidity (defined as average annual turnover). In line with Amihud et al. (2005), the evidence suggests the measured average decline in turnover is concentrated almost entirely in the lowest two quintiles of market capitalization and in the most liquid stocks.

Finally, in Table 1.7 I attempt to discern between the two types of retiming avoidance effect (anticipation shifting of transactions around the implementation date and lock-in/deferral effects persisting after implementation). In particular, I define temporary anticipation responses as the difference between the measured change in turnover immediately around implementation and the change over more distant months, which represent a change of a more permanent character, that I refer to here as the permanent lock-in effect (the online Appendix includes an illustration of this distinction). This definition of temporary anticipation thus captures a purely transitory change in turnover around implementation, without relying on assumptions about pre-treatment trends. The estimates for permanent lock-in are presented in the second column under each case in Table 1.7. The presence of a temporary retiming effect on regulated exchanges can be matched visually to the

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15The weights for each comparable company were chosen so as to minimize the predictive error between a combination of peer turnover and that of the treated stock during 2 years before the implementation of the tax.

16From the prior month to the first month the new tax enters into force.

17From the second to last month before implementation (t-2 months) to the second month of implementation (t+2).
missing 6% mass in the first month after the implementation of the tax in France in Figure 1.3. Surprisingly, this missing mass post-implementation is not mirrored by a spike in trading volumes in the month immediately before the reform. There are multiple possible explanations for this observation. Firstly, in contrast to larger over-the-counter trades, the need for a significant proportion of on-exchange trades may be unpredictable several weeks in advance from any individual portfolio’s perspective; this is especially accurate for high-frequency traders, who base their trading strategies entirely on intraday market opportunities. Secondly, there may be several behavioral biases at play, including a disposition effect - such that investors may be more likely to hold off buying/selling taxed assets post-reform to avoid realizing the tax itself as a perceived loss-, or an initial overreaction to the presence of the tax.

In the third and last column under Italy I measure the magnitude of a permanent (lock-in) second round of turnover drop around June 1st, 2013, which I argue in section 1.3 may help us identify some response of cash equity trading with respect to expectations of derivative taxation.

As seen both in the last column of Table 1.6 and on Figure 1.4, I find no such reduction in trading for Italian stocks following the reform. In section 1.3 I explain that this is likely a result of the more complex combination of tax wedges used in the Italian version of the FTT design, which offset much of the otherwise expected decline of on-exchange trading. Contentious general elections in Italy at the end of February could be raised as a concern for the identification of the specification above, since other confounding factors could be at play. However, concerns over political stability in Italy would, if anything, have spurred trading in Italian securities (albeit due to pessimistic valuation changes), thus implying that any turnover reduction impact estimates are a lower bound of their true value absent the elections.

Over-the-counter

Over-the-counter markets encompass inter-dealer trading outside of formal exchange platforms. As such, they do not use centralized trading mechanisms (such as auctions or limit-order books) to aggregate bids and offer trades; rather transaction terms are negotiated privately, with no immediate reporting requirements or supervisory authority - customization of transactions is thus more easily available,
but the overall procedure is also more opaque relative to on-exchange trades\textsuperscript{19}. Dealers have an increased incentive to participate in OTC mechanisms, even for stocks listed on public exchanges that are highly liquid, given the higher profitability of intermediation in OTC. From a client standpoint, OTC provide a platform where large block trades in a stock can be executed while minimizing price impact. It is important to note, however, that OTC markets present much higher heterogeneity than traditional exchanges. In particular, OTC includes crossing networks and the “upstairs market”, but also increasingly popular dark pools, which are direct business competitors to traditional exchanges. Conditional on price impact costs, commission fees charged and access cost for each of these segments need not be equivalent; by focusing on a single representative measure of OTC trading, the analysis below is hence oversimplifying the true market microstructure. In Europe, firms are increasingly trading internally, against own accounts, and as of 2013 make up to 40\% of all cash equity trading in Europe, on average\textsuperscript{20}. Under the second round of MiFID\textsuperscript{21}, OTC transactions have been subject to reporting requirements similar to those of registered exchanges (albeit with a time delay) starting in 2015; anticipatory effects of this legislation could translate into an upward trend in OTC “reported” volumes, even if true trading levels had remained constant. In the analysis in Table 1.8, the time and group fixed effects should absorb any such variation (and would only bias the results if such a trend change in reported volumes were systematically different for the treatment and control groups).

Over-the-counter prices track on-exchange prices virtually all the time (as expected, since if that were not the case, there would be large unexploited arbitrage opportunities on the table), so I refrain from including OTC asset valuation estimates in this section, which would be equivalent to the results presented above. Therefore, I focus the analysis of OTC activity on trading volume and subsequently, volatility measures akin to those used for lit markets. The data I use covers OTC transactions reported to Markit BOAT, a trade reporting platform that covers approximately 25\% of all cash equity reported activity in Europe (including lit markets). The drop in OTC trading is much more pronounced in Italy than in France in great part due to the tax wedge created by the legislation in Italy, which taxed OTC transactions at double the rate on lit platforms. Effectively, the turnover effect in OTC in Italy is on the order of a 85\% drop relative to the Spanish control group; in France, the drop rounded to 26\% of pre-reform OTC trading volumes. More importantly for the iden-

\textsuperscript{19}Derivative OTC trading is also affected by higher counterparty risk due to the lack of minimum margin requirements; parallel settlement concerns for vanilla equities arising from naked short sales, for instance, are equally present in OTC and regulated trading venues.

\textsuperscript{20}Thomson Reuters - European Market Share Reports

\textsuperscript{21}Directive on Markets in Financial Derivatives
tification of behavioral responses in the next section, virtually all of the response in French OTC turnover was temporary, vanishing by September 2012. As mentioned in the preceding section 1.3, this represents temporary anticipation of transactions which could be foreseen a few weeks ahead by OTC participants engaged in lumpier and larger block transactions. Once the tax was in place, however, the effective increase in average transaction costs for OTC participants captured in this analysis was proportionally much smaller than for on-exchange traders, and still satisfied the OTC participation constraint, leading to no permanent lock-in effect in France in the absence of other distortions. In contrast, the massive drop in Italian OTC was sustained several months after the introduction of the tax wedge (Figures 1.5 and 1.6).

Identification of behavioral responses

Combining the variation in policy design in both natural experiments analyzed in the preceding sections, I derive a range of estimates for each different elasticity that, as previously contended, I expect to play a role in explaining the underlying behavioral response to the tax. In particular, I aim at identifying elasticity ranges for realization anticipation, deferral/lock-in, avoidance through mechanism/platform shifting (from OTC to Lit), and instrument shifting (towards economically equivalent derivative contracts). Furthermore, I propose a strategy to identify the lock-in effect of high-frequency transaction taxes, separately from the lock-in effect induced by financial transaction taxes applied based on end of day ownership transfers of stock.

The present exercise is intended to function principally as a guide for structuring our understanding of the relative magnitudes of underlying behavioral responses within financial transaction tax avoidance. I am aware that the exact ranges provided are sensitive to the estimates obtained in this study and the assumptions I needed to make regarding the microstructure of the OTC and lit markets, but see it as a first step in obtaining informative policy and welfare-relevant parameter estimates, rather than simply net aggregate responses.

Portfolio substitution

As I described in section 1.3, I use the change in asset values following the announcement of the tax as a proxy for the degree of real portfolio substitution away from taxed assets. The intuition is that, conditional on fixed short-run supply of outstanding shares, changes in net aggregate demand for taxed assets (in other words, portfolio substitution pressure) once information was publicly available should be
captured by changes in asset prices. The empirical valuation results suggest this response channel was very small (price elasticity with respect to the tax was -0.075). Most importantly from the perspective of correctly capturing the magnitude of true avoidance (rather than substitution) responses post-implementation, I argue any portfolio substitution should have occurred before the actual implementation date of the tax. Rationally, unwinding a position (to substitute away from these assets) after the tax was in place would be more costly than before. Forbes et al. (2012) document a similar “front-running” behavior by investors in anticipation of a tax on capital inflows in Brazil. Thus, the core control groups used in this study (which can be considered substitutes for their treatment counterparts) should not be affected contemporaneously by a portfolio reallocation response around implementation. Our empirical estimates of turnover change in section 1.3 are hence taken as measures of net avoidance and evasion responses.

Evasion

Firstly, in order to deal with potential evasion responses being erroneously taken for avoidance behavior, I assume that Italy and France have similar evasion costs and elasticities. Furthermore, I contend it is unlikely that significant underreporting evasion exists in financial transactions of focus in this study given counterparty reporting and the inherent digital trail. In addition, most non-domestic trading of French and Italian equities is done in so-called “white exchanges” thanks to the introduction of MiFiD in 2007, which have standing agreements to not only provide information on trades executed by non-resident agents, but also to enforce applicable obligations they may be subject to in their domicile. Moreover, in contrast to earlier designs of FTTs in the 20th century, the latest reforms determine tax liability under an issuance principle (incorporation of the firm issuing the securities traded), rather than residence or source principles, more susceptible to cross-border manipulation; against this background, significant geographic evasion seems implausible. Finally, exchanges in third countries may be significantly less liquid in the taxed assets than the respective domestic exchanges, thereby deterring cross-country shifts due to higher transaction costs abroad. Corroborating this argument, the ADR exercises above show no credible evidence supporting an evasion story\(^{22}\), which may attest to expected US compliance with European tax enforcement demands. Similarly, trading in taxed French shares declined even more sharply in non-domestic exchanges (such as London - by 66% - and Frankfurt - by 52%) than in Paris, relative

\(^{22}\)Under geographic evasion, we should expect a significant drop in trading volume of domestic stocks relative to their ADR counterparts - especially in France's case, where they were de facto temporarily exempt. The empirical analysis does not support this hypothesis.
to untaxed Dutch control stocks, as shown in the online Appendix. I am hence ruling out significant evasion opportunities and focus instead in what follows on capturing avoidance.

Market-making exemptions

Even under a uniform tax rate in both OTC and on-exchange (such as the French case), we could expect a shift of transactions from OTC to lit markets due to the exemption of transactions resulting from market-making activities from the scope of the tax. A market maker (MM) is “a person who holds himself out on the financial markets on a continuous basis as being willing to deal on own account by buying and selling financial instruments against his proprietary capital at prices defined by him” (article 4.1(8) MiFID, European Parliament and Council (2004)). They are designated by or registered as such on registered exchanges. However, OTC traders also benefit from the exemption under the French legislation, as long as they operate in a similarly liquidity-providing function to that of registered exchanges’ market makers. These are also known as systematic internalizers (SI), defined as “an investment firm which on an organized, frequent and systematic basis, deals on own account by executing client orders outside a regulated market or an MTF” (article 4(7) MiFID, 2004). Effectively, the core difference between the two types of brokers is that a SI does not have to be designated by an exchange, and is free to create its own trading rules, including acting as a SI across multiple jurisdictions without needing further exchange approval.

Since the set of broker institutions considered systematic internalizers OTC overlaps to a great extent with that of market makers on investment exchanges (in other words, the exempt institutions are almost identical), I argue that this must not in fact have been a dominant dynamic in France\textsuperscript{23}. Moreover, the lack of a significant permanent lock-in effect on turnover OTC in France supports this contention, in that no shifting outside of OTC seems to have occurred as a result of the FTT in France, where there were no cross-platform tax arbitrage opportunities. In Italy, however, systematic internalizers were not exempt from FTT, implying indeed an incentive to shift trades to regulated exchanges if able to claim them under market-making purposes. According to a study by the Association of Financial Markets in Europe, about 40% of all reported OTC trading (which in itself accounts for an average of 40% of total reported trading volume in equities in Europe) corresponds to

\textsuperscript{23}In addition, I implicitly assume the corresponding share of market-makers and systematic internalizers to total on-exchange and OTC participants, respectively, must have been comparable. Otherwise, we should expect a bigger overall lock-in effect in the platform with the smallest fraction of exempt counterparties.
CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY'S FINANCIAL TRANSACTION TAXES

trades executed by systematic internalizers and crossing processes/network trades. Equivalently, at most 40% of all OTC trading in Europe corresponds to trading by systematic internalizers. I take this ratio as a proxy for the proportion of OTC that may have been open to shifting from OTC to on-exchange platforms due to greater market-making exemptions in the latter. In other words, with an average of 30% of pre-FTT equity volume in Italy being traded OTC, I allocate an upper bound of $40\% \cdot 30\% = 12\%$ of total pre-FTT volume as having shifted platforms towards lit markets. This leaves a minimum of $85\% - 40\% = 45\%$ of pre-FTT OTC volume which shifted to lit markets due to the tax rate differential between OTC (0.2%) and regulated markets (0.1%). This is likely to have been the determining factor explaining the bulk of the decline in trading volume OTC in Italy, as it was invariably the justification highlighted in press commentaries and reviews of the impact of the law by practitioners. The lack of a sizable anticipation shifting response in the Italian OTC market (in contrast to the one observed in France) can be justified by the alternative avoidance opportunity of shifting towards lit markets, which likely involved some fixed costs; as discussed below with respect to derivatives, those participants who chose to shift towards lit markets in Italy (almost everyone except exempt pension funds) would have done so once and completely at implementation, rather than combining mixed avoidance strategies within a short time window, since alternative sheltering options tend to be polarizing under the presence of fixed costs (Cowell (1990)).

Identification premises

My pivotal assumptions are common retiming (anticipation and lock-in, OTC and lit), platform and derivative shifting elasticities across the two case studies. I have no reason to expect the retiming response to be different in the two countries (controlling for the respective applicable rates). In addition, I allow retiming to vary between OTC and lit markets, since OTC participants might represent more long-term asset holders, less affected by FTT, such as certain types of pension funds (in Italy most non-exempt parties can switch to lit markets given the tax wedge between platforms, with those agents remaining likely to be pension funds, for example), or have access to different avoidance technologies.

Furthermore, I non-trivially assume that the HFT and the main FTT of 0.2% affect mutually exclusive group of traders, since algorithmic (high-frequency) trading typically takes advantage of intraday misalignments in quotes, ending the day with

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24These are defined as internal electronic matching systems, operated by investment firms, which execute client orders against other client orders or house account orders.
unchanged net positions, which are the base of the FTT. Moreover, I use survey estimates from the Committee of European Securities Regulators that up to 40% of all equity volume on registered exchanges corresponds to high-frequency trading (2010). Although this was an upper bound in 2010, the increasing trend of HFT likely makes this a conservative estimate for 2012-13. I require the relative composition of market participants by type to be unchanged after the introduction of the tax.

Therefore, I posit that any discrepancies between observed figures in the empirical estimations in section 1.3 (namely the different lock-in and anticipation responses both on-exchange and OTC in the two countries) arise due to different avoidance opportunities through the two channels aforementioned (platform and derivative shifting), as well as different tax rates on high-frequency trading. I exploit the cross-country variation in tax arbitrage opportunities and survey proxies for the share of market-maker-like participants in OTC and high-frequency traders in exchanges to separately identify the magnitude of each behavioral response. Diagram 1.7 summarizes the responses identified in this section. All elasticities are calculated with respect to a change in marginal tax rates (MRT) relative to transaction costs, whose estimates average 0.75% of asset values, except for high-frequency trading costs, estimated at 0.2%. Calculating elasticities directly with respect to the marginal tax rate change (similar to what is commonly done in the capital gains tax or VAT literature) would yield astronomically large semi-elasticities ranging from -30 to -4500. I compute confidence intervals for each elasticity estimate and the latter’s sensitivity to changes in the underlying assumptions about market structure in the online Appendix.

Over-the-counter

We restrict our focus to platform shifting for the moment (the first part of the diagram above). Out of the observed 26% OTC drop in France, I estimated its entirety to be due to retiming of transaction realizations around implementation (in other words, temporary anticipation). This implies that the permanent lock-in effect OTC was null following the introduction of the 0.2% FTT. This may be in part due to the generous market-making exemptions given by the French law, but also to the more

25The rationale for using transaction costs rather than the full notional value of the asset as a base for elasticity computations is that rather than accruing to the overall value or cost of the asset per se, transaction taxes increase the resources needed to enter into any transaction. Transaction taxes represent a marginal cash cost that cannot be offset against any stock borrowing or netting of asset purchases with a given counterparty. In other words, as a trader I care how many more resources I will have to invest as transaction costs in proportion to what I used to, conditional on any trade notional value.
flexible features of OTC contracts which may aid in curtailing the need for deferral. More intuitively, traditional crossing-networks and the “upstairs market” (the historical bulk of OTC markets\(^{26}\)) faced higher pre-existing transaction costs (including spreads due to asymmetric information and broker fees) than a standard institutional investor on-exchange. In addition, the lower expected frequency of transaction execution OTC relative to on-exchange likely meant lower expected incidence in present value terms, thus still fulfilling OTC traders’ participation constraints. The results are therefore not consistent with the hypothesis that transactions shifted from OTC to lit markets in France due to more generous market-making exemptions in the latter.

By assumption, the over-the-counter lock-in elasticity is the same in both countries (\(\sim 0\%, \text{ per the previous paragraph}\)), while the market-making shift from OTC to lit can range from 0\% up to 40\% in Italy, due to the stricter market making restrictions in the Italian FTT design. Hence, the remaining difference between the observed OTC permanent decline percentages \([-45\%, -85\%]\) and 0\% for Italy and France, respectively), can be attributable to the differential tax treatment of the two platforms in Italy. This result enables us to compute lower and upper bounds on the platform shifting elasticity due to changes in relative tax rates:

\[
\epsilon_{\text{platform}} = \frac{\% \Delta \text{OTC drop attributable to platform shifting}}{\% \Delta \text{MTR wedge between OTC and lit/ATC}} \in [-45\%, -85\%] \left[\frac{0.22\% - 0.12\%}{0.75\%}\right] = [-3.375, -6.375]
\]

Moreover, absent alternative dominant avoidance strategies, we can also derive an estimate for the anticipation response elasticity over-the-counter,

\[
\epsilon_{\text{OTC anticipation}} = \frac{\% \Delta \text{OTC anticipation drop}}{\% \Delta \text{MTR increase OTC/ATC}} = \frac{-26\%}{0.2\%/0.75\%} = -0.975
\]

In fact, because of the informational asymmetry inherent to OTC trading, spreads (a fundamental component of non-tax transaction costs) are typically higher than on exchanges, implying a larger initial share of transaction costs to notional value than 0.75\% (\text{Matheson (2011)}). This implies the elasticity estimates just computed could be underestimating the true magnitude of the response OTC. Intuitively, a temporary large anticipation response OTC is congruent with large profit margins per trade and the ability to forecast transaction execution needs a few days or weeks in advance in a lumpier market (which in contrast, high-frequency traders cannot do on-exchanges).

\(^{26}\)The rise of dark pools in recent years has changed this composition.
CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY’S FINANCIAL TRANSACTION TAXES

Registered exchanges - lit markets

While the total estimated decline in lit turnover in France was in the order of 24%, 18% was captured by a long-term lock-in effect, leaving only 6% as possible temporary anticipation response. To the extent that there is a subset of investors with fixed portfolio reallocation dates which may not correspond to the tax reform months, the 6% figure may underestimate the true magnitude of anticipatory behavior. Thus, we have

$$\epsilon_{\text{FTT, anticipation}} = \frac{\% \Delta \text{lit anticipation drop}}{\% \Delta \text{MTR increase lit/ATC}} = \frac{-6\%}{(0.2\%/0.75\%)} = -0.225$$

which is rather low relative to the other behavioral elasticities estimated in this section. Note that in Italy we could not measure any significant anticipation response, which may be due to the confounding effect of the general elections increasing trading volume in the implementation month (March). For this reason, I chose the more precisely estimated French parameter estimate of anticipation elasticity for the calculation of the anticipation elasticity on lit markets.

In turn, the lock-in figure for on-exchange trading masks two different underlying marginal tax rates: high-frequency trading (HFT) at 0.01% and overnight changes in stock ownership at 0.2%. In order to disentangle the two behaviors, I resort to the assumption of mutually exclusive target groups for each tax, as stated above, and use European survey averages to proxy for the share of high-frequency traders. In theory, the observed total lock-in effect in any given exchange with both types of taxes could be thought of as a weighted average of the respective marginal tax rates and group-specific turnover elasticities. For notational simplicity, I will denote non-HFT trading volume as “FTT”. For a single exchange, we thus have formally

$$HFT\_\text{share} \cdot HFT\_\text{MTR} \cdot \epsilon_{\text{Lock-in}}^{HFT} + FTT\_\text{share} \cdot FTT\_\text{MTR} \cdot \epsilon_{\text{Lock-in}}^{FTT} = \text{Observed overall lock-in}$$

For a single country, the elasticity parameters of interest are indeterminate, since we have one equation in two unknowns. However, by combining the evidence of the two case studies covered in this paper, I am able to identify each elasticity separately, conditional on the assumptions described in previous paragraphs. In order to ensure we combine results from equivalent markets, I match the Italian $\hat{\beta}_3^{\text{Lock-in LITTT}}$ estimate (the computed value for the observed permanent decline in turnover) with

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27 For instance, portfolios with a set reallocation schedule for June and September may have anticipated September realizations to June, but this would not be reflected in the estimates.

28 Weighted by the respective share of participants from each group.
that for the French 5th turnover quintile, which is most similar to the average Italian turnover levels. As highlighted previously, both the empirical evidence shown here and theoretical models suggest that, all else equal, lock-in elasticities with respect to a transaction tax should be larger for stocks with higher turnover. Thus, we have

\[
\begin{align*}
\text{France}_T5 : & \quad 40\% \cdot \frac{0.01\%}{0.2\%} \cdot \epsilon_{\text{Lock-in}}^{\text{HFT}} + 60\% \cdot \frac{0.2\%}{0.75\%} \cdot \epsilon_{\text{Lock-in}}^{\text{FTT}} = -31\% \\
\text{Italy :} & \quad 40\% \cdot \frac{0.02\%}{0.2\%} \cdot \epsilon_{\text{Lock-in}}^{\text{HFT}} + 60\% \cdot \frac{0.1\%}{0.75\%} \cdot \epsilon_{\text{Lock-in}}^{\text{FTT}} = -42.5\%
\end{align*}
\]

where the 42.5% decline of on-exchange turnover in the second line is derived by subtracting the OTC to lit shift in Italy discussed earlier (85% \cdot \frac{1}{3} \cdot \frac{3}{5} = 42.5\% of pre-reform lit volume) from the observed drop of 0%. The 31% decline for the 5th French turnover quintile corresponds to the overall observed lock-in decline for the group. Since high-frequency trading largely bypasses the need for broker intervention by relying on algorithmic trading technology, commission fees are substantially lower than for traditional sales traders (Kim (2007)). Furthermore, as high-frequency trading institutions compete to provide liquidity, they take a significant part of the bid-ask spreads as profit, rather than costs. Therefore, overall transaction costs are in theory much lower for HFT than regular sales traders. Unfortunately, I am unaware of reliable empirical estimates of such costs, and as such limit myself to consider the elasticity estimate below as an upper bound; anecdotal evidence however suggests it could be at least 80% smaller (Blawat (2012)). Moreover, these lock-in elasticities are still “contaminated” by shifting to derivative contracts, which cannot be captured given the existing variation. The estimate of the derivative shifting elasticity at the end of this section refers to the elasticity of cash equity transactions with respect to an increase in the tax wedge between economically equivalent derivative transactions and cash equities, and makes an important assumption regarding the informationally-driven source of a second round of turnover drop on the Milan stock

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29In other words, I assume the non-HFT lock-in elasticity to be the same for the two subsamples.
30Given OTC pre-reform accounted for about a third of total cash equity volume in Italy.
31The equivalent treatment effect presented on Table 1.7, estimated exclusively within the 5th turnover quintile. Note that this permanent lock-in is approximately 3.5% higher than the immediate effect (equivalent to negative anticipatory response), implying a potential delayed adjustment by less sophisticated investors in very liquid stocks, which may have taken longer to wind down their positions (either because of salience of the measure only in August, because of vacation-related absence from the market, or other reasons).
exchange. Solving for each elasticity parameter, we get

\[
\begin{align*}
\epsilon^{FTT}_{Lock-in} &= \frac{\% \Delta \text{lit lock-in drop for non-HFT}}{\% \Delta \text{MTR increase lit FTT/ATC}} = -0.8125 \\
\epsilon^{HFT}_{Lock-in} &= \frac{\% \Delta \text{lit lock-in drop for HFT}}{\% \Delta \text{MTR increase lit HFT/ATC}} = -9
\end{align*}
\]

The much larger elasticity for HFT transaction volumes, orders of magnitude beyond what the public finance literature is accustomed to see, can be explained by the relatively low cost of response under sophisticated technology available to these types of agents\(^{32}\), but most importantly by the relatively high impact of the tax (even at a rate of 0.01%) on the profitability of HFT. The latter often exploit infinitesimal mispricing to make marginal gains that accumulate with order volume throughout the day - a not-so-infinitesimal tax takes a chunky bite off these profits that make HFT worthwhile, thus eliciting a much stronger response to a transaction tax than in more conventional trading floor operations. This result is also consistent with recent work by Deng et al. (2014), which find that sophisticated institutional traders dominate mature markets in Hong Kong, where their discouragement under the presence of transaction taxes is associated with higher price volatility.

**Instrument shifting**

Finally, I aim at identifying the magnitude of avoidance behavior via instrument shifting. While different possible combinations of derivative contracts could in theory be used to substitute for cash equity transactions (call-put option combinations, forward contracts, etc), the most straightforward and common derivative for the purposes just described are swaps known as contracts for differences (CFDs). CFDs stipulate that the contract seller will pay to the buyer the difference between the current value of an asset and its value at contract time. Thus, they can be used to gain exposure to price movements of the underlying asset without any of the parties involved actually even having to own it. In addition, they use leverage, trading on margin rather than cash positions. Unlike futures contracts, CFDs have no fixed contract size and no expiration date, making them attractive to investors seeking flexible arrangements. CFDs are illegal in the US but are widespread in Europe, providing thus an easy avoidance channel for both the French and Italian FTTs. Certainly broadening the applicability of an FTT to derivatives (as in the Italian case) ought to diminish opportunities for this kind of avoidance. Notwithstanding, tax arbitrage is still possible as long as assets are taxed differently.

\(^{32}\)In fact, these agents “are technology” in the sense that algorithmic trading orders are executed by massive high-speed computers.
I could not identify derivative shifting elasticities from trading volumes for derivatives contracts, since virtually all CFDs are executed over-the-counter and do not have any reporting requirements currently in place. An analysis of changes in volume of standard exchange-traded options is inconclusive - see the online Appendix for detailed results. I further conducted difference-in-differences estimation exercises for cash equities around the entry into effect of the derivatives tax in Italy on September 1st, 2013, but found no significant effects. A plausible explanation for this is the limited time (four months) of derivative tax exemption relative to cash equities, making it not worthwhile for traders to shift instruments for hedging or other purposes only temporarily. If they were to shift to derivatives, they would do so fully and permanently (Cowell (1990)), since there are likely fixed costs involved. In addition, even after derivatives came under the scope of the tax, the relative tax rate remained favorable towards derivatives (since at most the marginal rate for the latter would be 0.02% of notional contract value), reinforcing the hypothesis that if a trader chose to shift initially, she would do so permanently. Nonetheless, the two stage evolution of lit turnover in Italy after the initial implementation of the cash equities FTT does suggest derivatives avoidance played a role in the second round of turnover decline around the beginning of June 2013. Notably, from June 1st onwards a series of articles in the Italian and international press announce the postponement of the implementation of the derivatives tax from July 1st, as previously expected, to September 1st. Amidst a background of general uncertainty about the permanent character of the tax (and in particular whether derivatives would come under its scope), I argue that a plausible consequence of this announcement was to reinforce expectations that the tax was to stay. In addition, the announcement news is likely to have augmented the salience of derivatives shifting as an avoidance opportunity. I view this as an incentive to switch towards derivatives for those that had not yet done so in March, and use this parameter to identify a lower bound on equity turnover elasticity with respect to derivative taxes. Simple adjustment lag stories, uncertainty over how the tax was to be levied technically speaking or delayed first round of tax collection (retroactive) are rejected by the fact that neither the OTC market in Italy, nor any of the French trading platforms exhibited a similar second round of behavioral response - the only tangible difference between this case

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33 Detailed estimation results can be obtained upon request from the author.
34 This implicitly assumes a common fixed adjustment cost or at a minimum one with a fairly narrow dispersion among traders.
35 Both France and Italy had a delay of about 3 months between the date of implementation of the FTT and its first round of payment collection (the dues for the interim months were paid simultaneously).
and the others is the looming of a derivatives tax\textsuperscript{36}. The intensity of web searches near Milan for derivative related terms in June 2013 - in particular for the name of some of the most well-known contract-for-differences providers in Italy, such as IG Italia and Plus500 - corroborates this interpretation (the online Appendix includes this graphical evidence).

Hence, the corresponding estimate for derivative shifting elasticity in equity markets is

\[
\epsilon_{\text{derivative}} = \frac{\% \Delta \text{lock-in drop upon derivative announcement}}{\% \Delta \text{MTR wedge between lit and derivatives/ATC}} = \frac{-18.6\%}{[(0.1\% - 0.02\%)/0.2\%]} = -0.465
\]

, where the denominator is the maximum possible effective marginal tax rate imposed on an eligible derivative contract under Italian law.

1.4 Policy Implications

The evaluation of the introduction of an asset-specific transaction tax reform such as the one described above has direct implications for our understanding of optimal taxation of financial activity. While a comprehensive design of a first-best tax structure in the sector is beyond the scope of this paper, there have been a few recent forays into this literature, among which I highlight Dávila (2013), summarized in section 1.3. While the author proposes a closed-form solution for the optimal linear Pigouvian FTT, in practice we should consider not only the optimal tax from a corrective standpoint, but also with an objective of maximizing government revenue. The simple case where the government aims exclusively at maximizing revenues accruing from a linear tax with a tax base responsive to the tax rate gives us an optimal rate of \( \tau^{\ast} = \frac{1}{1 + \epsilon} \), where \( \epsilon \) would be the elasticity of nominal volume transacted with respect to a change in the net of tax rate\textsuperscript{37}. In this context, the presence of avoid-

\textsuperscript{36}Estimating the same difference-in-differences specification for turnover of Italian companies just below the €500m threshold yields a non-significant decline smaller than the estimated June lock-in for high market cap companies shown in the last column of Table 1.7; this suggests any move towards derivatives captured in June would not have been a shift towards equity trading of exempt Italian companies, but rather a reduced overall lock-in effect.

\textsuperscript{37}In chapter 2 I formally derive this revenue-maximizing rate under a portfolio selection model. There \( \epsilon \) corresponds to the sum of the implied price elasticity upon announcement of the tax, and both the permanent lock-in and temporary anticipation effect (in a single risky asset, single market, non-HFT setting). Mapping the sufficient statistics from this theoretical model to the parameters estimated empirically here, we get \( \tau_{RM}^{\ast} \approx 0.67\% \), above currently imposed rates or most of those under discussion (\( \approx 0.1\% \)).
ance behavior to an alternative taxed at rate $t \leq \tau$ will alter the optimal linear tax formula by adding an extra term to the numerator, such that $\tau^* = \frac{1 + t \cdot s \cdot \epsilon}{1 + \epsilon}$, where $s$ is the fraction of the response due to income shifting (Saez et al. (2012)). Feldstein (1999) argues that if the alternative tax rate is 0, then it is irrelevant whether we observe “real” or avoidance responses. However, if $t > 0$, then $\tau^* > \frac{1}{1+\epsilon}$, due to the fiscal externality involved. At an optimum, $t = \tau$ and $\tau^* = \frac{1}{1 + (1-s) \cdot \epsilon}$, where $(1-s) \cdot \epsilon$ corresponds to the “real” elasticity of trading volume (the “lock-in elasticity” in the present context). The optimal financial transaction tax rate depends also on other pre-existing taxes on financial assets, such as the more widespread capital gains or dividend taxes, which I abstract from in this version.

To get an idea of what the fraction of the observed response may be due to income shifting ($s$), I resort to a back-of-the-envelope computation for each country in the sample used here, drawing on the estimates from section 1.3. Specifically, we know both the original official estimates of government revenue accruing from the introduction of the tax, and the actual respective shortfalls (since actual receipts were much lower than anticipated). Assuming the original government estimates were predicated on purely mechanical factors\(^\text{38}\), we can subtract the turnover decline in each market platform (multiplied by the respective average marginal tax rate) to compute behaviorally-corrected expected government revenue figures. In the case of France, original official estimates were for revenues of €530 million\(^\text{39}\), in contrast to the actual receipts over that period of approximately €250 million\(^\text{40}\). Adding the permanent decline in regulated exchange turnover and the temporary anticipation effect OTC, we have

\[
-26\% \cdot \text{OTC Aug 2011} \cdot 0.2\% \cdot 24\% \cdot \text{Lit 2011} \cdot (0.01\% \cdot 40\% + 0.2\% \cdot 60\%) = -€144.3m
\]

\[\Rightarrow \mathbb{E}_{\text{Adjusted (Revenues)}} = €530m - €144.3m = €385.7m\]

For Italy, we correct the original estimates of €1 billion\(^\text{41}\) for the decline observed OTC\(^\text{42}\), which brings us closer to the actual lower receipts of €200 million:

\(^{38}\)Mechanical responses are understood as those excluding any of the behavioral responses identified in this paper, such as retiming and tax arbitrage.

\(^{39}\)From August 1, 2012 through the end of that calendar year.

\(^{40}\)I use the total euro value of trading volume (i.e., number of shares multiplied by closing daily price) for the affected companies in those same months in the preceding year (2011) as the ex-ante tax base. For the temporary anticipatory response OTC, the posited expected tax base is the total euro value of trading volume OTC in August. Note that I continue to use the assumed percentage of high-frequency trading in regulated markets of 40% to calculate the relevant average marginal tax rate.

\(^{41}\)From March 1, 2013 through December 31, 2013.

\(^{42}\)Using as the ex-ante tax base March through December 2012 trading volumes in euros.
CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY’S FINANCIAL TRANSACTION TAXES

\[-85\% \cdot \text{OTC 2012} \cdot 0.2\% = -€442.51m\]
\[\Rightarrow E_{\text{Adjusted}}(\text{Revenues}) = €1bn - €442.51m\]
\[= €557.49m\]

We are thus able to account for \(\frac{144.3}{280} = 51.52\%\) and \(\frac{442.51}{800} = 55.31\%\) of revenue shortfalls in France and Italy, respectively. Therefore, a significant share of the shortfall measured can be attributed to income shifting of some form. The remaining unexplained difference could be due to changes in average asset prices over the years of reform, macroeconomic factors affecting either volume or prices, measurement error, or lags in revenue collection, among others.

The results described in this paper are thus suggestive that the true optimal FTT from a revenue-raising objective might be lower than expected when looking only at the gross response of market turnover to an increase in transaction costs. Of note, HFT-targeted taxing may be relatively less worthwhile from a revenue raising perspective, given the massive avoidance response estimated for this type of market participants in this paper. Broadly speaking, two key characteristics stand out as predictive of high avoidance elasticities: low pre-existing transaction costs, and high average trading frequency - both typical features of HFT participants. Yet, insofar as HFT may be socially inefficient, there may be Pigouvian grounds for the taxation of HFT trading. However, it is questionable whether an FTT is the most well-targeted tool for such a correction, since it directly affects trading frequency and not trading speed (associated with most predatory trading strategies - see Harris et al. (2014)). On the other hand, more comprehensive policy designs may actually invert the former recommendation. By setting positive tax rates for common income shifting categories and limiting legal loopholes, Italy’s FTT design is likely to have weathered some of the revenue losses characterizing the French experience, without incurring further first order efficiency losses. Such an argument (obviating from any further macroeconomic and fiscal externalities) would support the introduction of higher rates, as long as available shifting categories are also taxed. This rate would then be added to the optimal Pigouvian rate à la Dávila (2013), since corrective taxes are additive with respect to optimal revenue raising taxes (Sandmo (1975); Kopczuk (2003)).

A few more insights arising from the empirical case studies are granted at this point. Firstly, comprehensive taxation across asset types and economically equivalent financial contracts is imperative to ensure compliance and avoid a shrinkage of the original tax base. Avoidance strategies are easily constructed to explore loopholes whenever tax-exempt instruments remain available. In this context, transactions that give rise to identical payoff patterns should be taxed at the same rates, in order
to mitigate substitution possibilities\textsuperscript{43,44}. In addition, mitigating avoidance involves guaranteeing cooperation across jurisdictions in enforcement of tax collection and reporting, even before considering cross-border tax harmonization\textsuperscript{45}. Cooperation is also critical to avoid double-taxation.

Secondly, as capitalization of the tax is higher for assets with higher turnover\textsuperscript{46}, a non-linear tax schedule as a function of asset turnover may be preferable to a linear and strictly proportional schedule\textsuperscript{47}, with stepwise rates lower for more liquid markets. On the other hand, more liquid markets may also face less obstacles to price discovery; in that sense, it could in fact be preferable to have higher rates for more liquid markets, since interference with information aggregation could arguably be smaller.

Moreover, the likely overestimation of revenues accruing from the introduction of a FTT (due to underestimated behavioral effects documented above) can be exacerbated by fiscal externalities not yet addressed by policy makers or the transaction tax literature. Namely, avoidance of the FTT via deferred realization of stock sales and use of derivative contracts such as CFDs lowers the effective capital gains tax rate incurred by asset holders, and migration of capital transactions to foreign markets completely eliminates any capital gains tax revenues formerly accruing from such trades. It would be an interesting empirical exercise to investigate whether capital gains tax revenues were somehow adversely affected by the introduction of the FTT. On balance, the fiscal losses of capital gains taxes may actually outweigh any perceived additional revenues from the FTT, further undermining the government revenue argument in its favor.

\section*{1.5 Conclusion and subsequent extensions}

I find very small substitution responses to the introduction of an FTT (as measured by changes in asset returns), but impressively large avoidance responses. Especially, I find huge temporary shifts in timing of transaction realizations over-the-counter, a sharp lock-in effect of high-frequency trading, and an almost complete defection from the market.\footnote{See Campbell and Froot (1993).}

\footnote{While CFDs are illegal in the US, other derivative strategies could still be used to circumvent a cash equity or fixed income FTT. Therefore, this recommendation is generalizable across legislative frameworks.}

\footnote{This message is corroborated systematically in the securities transaction tax literature.}

\footnote{As described earlier, this is a result of the fact that shorter holding periods allow for shorter amortization periods of the tax over the terminal asset value. In a world of liquidity clienteles, this differential is capitalized more heavily into more liquid assets.}

\footnote{Virtually all securities transaction taxes currently in place are linear for a given asset type.}
divergence of trading across platforms to exploit tax arbitrage opportunities. Overall, the behavioral responses measured in this paper suggest introducing financial transaction taxes with similar designs to those currently in place in France and Italy (especially the former), may be not be the best choice of tax instrument from a revenue raising perspective. However, such a tax may be welfare-enhancing as a Pigouvian tax if comprehensively designed to induce optimal trading behavior and mitigate avoidance loopholes. Notwithstanding, there may be alternative Pigouvian correction methods more directly targeted at any perceived externalities from financial market activities, including Budish et al. (2014)'s mechanism design solution to the high-frequency trading arms race over infinitely small improvements in order transmission times. Similarly, the core revenue inefficiency results in this paper through FTTs suggest the policy focus should shift towards alternative tax reforms applicable to financial sector activities that i) lend themselves less easily to widespread avoidance strategies and ii) are less distortive of underlying production decisions by economic agents in the sector (in a Diamond and Mirrlees (1971a) sense). One such alternative is a financial activities tax (FAT), in one of the variants proposed by Keen et al. (2010).

At a subsequent stage, I would like to expand the current analysis to estimate the impact of the tax on cost of capital and corporate funding decisions. In both instances analyzed in this paper, equity became relatively more expensive as a means of funding relative to debt, so a priori we would expect this measure not only to hamper investment by large firms in France (and thereby macroeconomic growth), but also to incentive firms to leverage (assuming the cost of debt remains constant). Under a non-behavioral model of the type used in Matheson (2011), a 0.2% FTT would be estimated to increase cost of capital by 0.8% at most, making it a second order consideration. Using a similarly simple dividend capitalization/perpetuity type model, Amihud and Mendelson (1992) conclude that 0.5% FTT could lead to a 1.33% increase in the cost of capital measured by the increase in required annual return due to higher bid-ask spreads. Evaluating changes in corporate funding decisions for the firms under the French and Italian FTT in the year following the reform (2013 and 2014, respectively) could shed light on the empirical validity of these hypotheses.

A distributional analysis of the incidence of the tax is yet another relevant topic of future related research. If large institutional traders have access to a broader range of

\[48\] While Devereux et al. (2013) find a type of FAT on bank borrowing performs poorly with respect to a Pigouvian objective of financial risk reduction, this is likely to be specific to the choice of FAT, and does not necessarily jeopardize the efficiency of this alternative from a revenue perspective.

\[49\] Assuming an average holding period of 3 months, close to the measured average holding period in my sample.
avoidance opportunities than non-institutional market participants (such as pension funds and retail clients), then the burden of the tax may fall disproportionately more on household savings, rather than reducing (as claimed by some policy-makers) excessive financial sector rents. From a generational perspective, elderly individuals are a priori more likely to bear a larger share of welfare losses, since they typically have relatively larger holdings of financial assets and a shorter investment horizon. In turn, this may have implications for the sustainability of funded annuity and pension plans, which have so far been ignored by the mainstream debate on the optimality of FTTs.

Finally, understanding the actual impact of FTTs on capital market efficiency and welfare per se merits further research. Dávila (2013) has cast doubt into whether volatility measures are informative about welfare losses in capital markets. Instead, based on a model where belief dispersion among investors gives rise to suboptimal non-fundamental trading, he suggests the dispersion of expected returns across investors is the single sufficient statistic for the optimal linear financial transactions tax. In turn, Banerjee (2011) shows cross-sectional evidence in support of investor disagreement being positively related to return volatility. Therefore, one could use variance of total portfolio returns as a proxy for the amount of non-fundamental trading being exercised by a given investor/institution - the type of “speculative” activity that an optimal FTT ought to target, since it can affect it most directly.
Table 1.1: Market Cap by Treatment Groups (Millions of Euros) - France

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<th>Treatment group</th>
<th>Quintiles of Market Cap</th>
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<th>3</th>
<th>4</th>
<th>5</th>
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Table 1.2: Market Cap by Treatment Groups (Millions of Euros) - Italy

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Table 1.3: Turnover by Treatment Groups (% of outstanding shares) - France

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<td>33</td>
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</tbody>
</table>

Table 1.4: Turnover by Treatment Groups (% of outstanding shares) - Italy

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Quintiles of Turnover</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spanish</td>
<td>Mean</td>
<td>0.17</td>
<td>0.40</td>
<td>0.67</td>
<td>0.96</td>
<td>1.76</td>
<td>0.78</td>
</tr>
<tr>
<td>N</td>
<td>13</td>
<td>10</td>
<td>11</td>
<td>13</td>
<td>11</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Italian</td>
<td>Mean</td>
<td>0.22</td>
<td>0.41</td>
<td>0.66</td>
<td>1.01</td>
<td>2.10</td>
<td>0.88</td>
</tr>
<tr>
<td>N</td>
<td>13</td>
<td>15</td>
<td>14</td>
<td>12</td>
<td>14</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Mean</td>
<td>0.20</td>
<td>0.41</td>
<td>0.67</td>
<td>0.98</td>
<td>1.95</td>
<td>0.83</td>
</tr>
<tr>
<td>N</td>
<td>26</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>126</td>
<td></td>
</tr>
</tbody>
</table>
### Table 1.5: Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), Prices

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abnormal Return Feb 7</td>
<td>Abnormal Return February 27</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>0.003** (0.001)</td>
<td>0.005** (0.002)</td>
</tr>
<tr>
<td>Announcement date</td>
<td>0.007*** (0.002)</td>
<td>0.007*** (0.002)</td>
</tr>
<tr>
<td>Treatment Effect - Announcement</td>
<td>-0.011*** (0.003)</td>
<td>-0.010*** (0.003)</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.015</td>
<td>0.018</td>
</tr>
<tr>
<td>Observations</td>
<td>825</td>
<td>825</td>
</tr>
<tr>
<td>Clusters</td>
<td>165</td>
<td>165</td>
</tr>
</tbody>
</table>

Standard errors in parentheses.

I find a significant negative effect of announcements over the introduction of a financial transactions tax in the order of 1% of daily returns of affected assets. I associate this effect with the asset substitution response of investors. This effect is much smaller than simplistic models of capitalization of transaction costs would have predicted.

Includes observations six months prior and following the announcement date, with an event window of 5 days around the latter.

Standard errors are clustered at the company level.

1st sample includes 108 French companies and 57 Dutch/Belgian. 2nd sample consists of 67 Italian companies and 56 Spanish.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Table 1.6: Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), Turnover by Quintiles

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Turnover Aug 1</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>Turnover Mar 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>0.152</td>
<td>-0.665</td>
<td>0.717</td>
<td>-0.359</td>
<td>0.561</td>
<td>0.125</td>
<td>0.091</td>
<td>-0.108</td>
<td>0.000</td>
<td>0.117</td>
<td>0.359</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>-0.030</td>
<td>-0.085</td>
<td>-0.007</td>
<td>0.040</td>
<td>0.044</td>
<td>-0.111**</td>
<td>-0.156</td>
<td>-0.175</td>
<td>0.082</td>
<td>-0.079</td>
<td>0.080</td>
<td>0.076</td>
</tr>
<tr>
<td>Month</td>
<td>0.281***</td>
<td>0.143</td>
<td>0.346***</td>
<td>0.251**</td>
<td>0.417***</td>
<td>0.316***</td>
<td>0.249**</td>
<td>0.278***</td>
<td>0.336***</td>
<td>0.311***</td>
<td>0.247***</td>
<td>0.097**</td>
</tr>
<tr>
<td>Month*Year</td>
<td>-0.471***</td>
<td>-0.206</td>
<td>-0.631***</td>
<td>-0.375**</td>
<td>-0.703***</td>
<td>-0.594***</td>
<td>-0.438***</td>
<td>-0.480***</td>
<td>-0.588***</td>
<td>-0.386***</td>
<td>-0.459***</td>
<td>-0.129**</td>
</tr>
<tr>
<td>Month*Treated</td>
<td>-0.083</td>
<td>0.174</td>
<td>-0.145</td>
<td>-0.133</td>
<td>-0.279***</td>
<td>-0.080</td>
<td>0.039</td>
<td>-0.159</td>
<td>-0.001</td>
<td>-0.193*</td>
<td>-0.070</td>
<td>-0.009</td>
</tr>
<tr>
<td>Year*Treated</td>
<td>-0.022</td>
<td>-0.031</td>
<td>-0.009</td>
<td>-0.025</td>
<td>-0.196</td>
<td>0.084</td>
<td>0.025</td>
<td>0.098</td>
<td>0.052</td>
<td>-0.005</td>
<td>-0.043</td>
<td>-0.012</td>
</tr>
<tr>
<td>Treatment Effect</td>
<td>-0.279***</td>
<td>-0.631***</td>
<td>-0.255**</td>
<td>-0.301</td>
<td>-0.027</td>
<td>-0.038</td>
<td>-0.284</td>
<td>-0.252</td>
<td>-0.249*</td>
<td>-0.300***</td>
<td>-0.320**</td>
<td>0.010</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.032</td>
<td>0.104</td>
<td>0.080</td>
<td>0.081</td>
<td>0.099</td>
<td>0.141</td>
<td>0.052</td>
<td>0.205</td>
<td>0.197</td>
<td>0.268</td>
<td>0.144</td>
<td>0.018</td>
</tr>
<tr>
<td>Observations</td>
<td>11513</td>
<td>2317</td>
<td>2379</td>
<td>2272</td>
<td>2308</td>
<td>2237</td>
<td>2317</td>
<td>2208</td>
<td>2166</td>
<td>2414</td>
<td>2308</td>
<td>8325</td>
</tr>
<tr>
<td>Clusters</td>
<td>165</td>
<td>34</td>
<td>34</td>
<td>32</td>
<td>33</td>
<td>32</td>
<td>34</td>
<td>33</td>
<td>31</td>
<td>34</td>
<td>33</td>
<td>125</td>
</tr>
</tbody>
</table>

Smallest market cap quintile

Highest turnover quintile

Standard errors in parentheses

This table shows a triple difference-in-differences estimate of the impact of the implementation of a financial transactions tax on equity turnover. The results show very large and significant negative effects on trading volume of taxed assets. Furthermore, as discussed in the text, this detrimental impact is heterogeneous across firm size and liquidity.

Includes observations one month prior and following the event date. I difference treatment and control groups, months and years to ensure I take into account any possible seasonality or macroeconomic events biasing the results.

Standard errors are clustered at the company level.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Chapter 1. Dodging Robin Hood: Responses to France and Italy’s Financial Transaction Taxes

Table 1.7: Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish),
Retiming: Lock-in vs Anticipation

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Turnover Aug 1</td>
<td>Lock-in Aug 1</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>0.152</td>
<td>0.095</td>
</tr>
<tr>
<td></td>
<td>(0.216)</td>
<td>(0.198)</td>
</tr>
<tr>
<td>Year</td>
<td>-0.030</td>
<td>0.118*</td>
</tr>
<tr>
<td></td>
<td>(0.065)</td>
<td>(0.061)</td>
</tr>
<tr>
<td>Month</td>
<td>0.281***</td>
<td>0.188***</td>
</tr>
<tr>
<td></td>
<td>(0.043)</td>
<td>(0.045)</td>
</tr>
<tr>
<td>Month*Year</td>
<td>-0.471***</td>
<td>-0.271***</td>
</tr>
<tr>
<td></td>
<td>(0.057)</td>
<td>(0.052)</td>
</tr>
<tr>
<td>Month*Treated</td>
<td>-0.083</td>
<td>0.125**</td>
</tr>
<tr>
<td></td>
<td>(0.055)</td>
<td>(0.056)</td>
</tr>
<tr>
<td>Year*Treated</td>
<td>-0.022</td>
<td>-0.035</td>
</tr>
<tr>
<td></td>
<td>(0.085)</td>
<td>(0.082)</td>
</tr>
<tr>
<td>Treatment Effect</td>
<td>-0.279***</td>
<td>-0.195***</td>
</tr>
<tr>
<td></td>
<td>(0.071)</td>
<td>(0.070)</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.032</td>
<td>0.008</td>
</tr>
<tr>
<td>Observations</td>
<td>11513</td>
<td>11182</td>
</tr>
<tr>
<td>Clusters</td>
<td>165</td>
<td>165</td>
</tr>
</tbody>
</table>

Includes observations one month prior and following the event date.
Standard errors clustered at the company level.

∗ p < 0.1, † p < 0.05, ‡ p < 0.01

I look at the short-term (one-month before and after reform) and long-term (two months before and after) turnover decline in taxed assets. The results presented here are consistent with a persistent detrimental effect of the tax on trading volumes on registered exchanges in France (rather than anticipatory retiming, and no (apparent) effect on Italian exchanges.

Standard errors in parentheses.

Includes observations one month prior and following the event date.

Standard errors are clustered at the company level.
**CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY’S FINANCIAL TRANSACTION TAXES**

36

Table 1.8: Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), OTC

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aug 1 2012</td>
<td>Lock-in Aug 1</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>-0.138</td>
<td>-0.037</td>
</tr>
<tr>
<td></td>
<td>(0.308)</td>
<td>(0.309)</td>
</tr>
<tr>
<td>Year</td>
<td>0.054</td>
<td>0.106</td>
</tr>
<tr>
<td></td>
<td>(0.082)</td>
<td>(0.086)</td>
</tr>
<tr>
<td>Month</td>
<td>0.418***</td>
<td>0.301***</td>
</tr>
<tr>
<td></td>
<td>(0.099)</td>
<td>(0.071)</td>
</tr>
<tr>
<td>Month*Year</td>
<td>-0.562***</td>
<td>-0.203**</td>
</tr>
<tr>
<td></td>
<td>(0.099)</td>
<td>(0.102)</td>
</tr>
<tr>
<td>Month*Treated</td>
<td>-0.314***</td>
<td>-0.140</td>
</tr>
<tr>
<td></td>
<td>(0.112)</td>
<td>(0.103)</td>
</tr>
<tr>
<td>Year*Treated</td>
<td>0.528***</td>
<td>0.161</td>
</tr>
<tr>
<td></td>
<td>(0.102)</td>
<td>(0.115)</td>
</tr>
<tr>
<td>Treatment Effect (Interaction)</td>
<td>-0.296**</td>
<td>-0.019</td>
</tr>
<tr>
<td></td>
<td>(0.125)</td>
<td>(0.135)</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.022</td>
<td>0.004</td>
</tr>
<tr>
<td>Observations</td>
<td>9020</td>
<td>8825</td>
</tr>
<tr>
<td>Clusters</td>
<td>138</td>
<td>139</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

The detrimental effect of the transaction taxes measured by my triple difference-in-differences estimation is even more pronounced when we look at the behavior in over-the-counter platforms. In Italy, OTC trading in taxed assets dropped permanently by 85%, while in France the observed decline of 26% represented pure anticipation of transactions to the month preceding tax enactment.

Includes observations one month prior and following the event date.

Standard errors are clustered at the company level.

* p < 0.1, ** p < 0.05, *** p < 0.01
Figure 1.3: France: High market cap Dutch and Belgian vs French turnover

Figure 1.4: Italy: High market cap Spanish vs Italian turnover
CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY’S FINANCIAL TRANSACTION TAXES

<table>
<thead>
<tr>
<th></th>
<th>Jun1</th>
<th>Jul1</th>
<th>Aug1</th>
<th>Sep1</th>
<th>Oct1</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1.5: France: Turnover OTC**

**Figure 1.6: Italy: Turnover OTC**
CHAPTER 1. DODGING ROBIN HOOD: RESPONSES TO FRANCE AND ITALY’S FINANCIAL TRANSACTION TAXES

Figure 1.7: Behavioral Elasticities Identification Diagram

OTC
- Common $\varepsilon_{\text{lock-in}}^{(\text{OTC})}$, $\varepsilon_{\text{anticipation}}^{(\text{OTC})}$
- French OTC measured retiming

Common $\varepsilon_{\text{platform}}$
- Share of liquidity providers OTC ≤ 40%
- Italian OTC measured retiming

Lit
- Common $\varepsilon_{\text{anticipation}}^{(\text{FTT})}$, $\varepsilon_{\text{lock-in}}^{(\text{FTT})}$, $\varepsilon_{\text{lock-in}}^{(\text{HFT})}$
- Share of high-frequency traders in lit markets = 40%
- French & Italian lit measured retiming

Common $\varepsilon_{\text{instrument}}$
- Salience of avoidance opportunity and permanent nature of taxation
- Italian Lit second round measured retiming

$\varepsilon_{\text{lock-in}}^{(\text{OTC})}$
$\varepsilon_{\text{anticipation}}^{(\text{OTC})}$
$\varepsilon_{\text{platform}}$
$\varepsilon_{\text{anticipation}}^{(\text{FTT})}$
$\varepsilon_{\text{lock-in}}^{(\text{FTT})}$
$\varepsilon_{\text{lock-in}}^{(\text{HFT})}$
$\varepsilon_{\text{instrument}}$
Chapter 2

Dynamic and Cross-Platform
Optimal Financial Transaction
Taxation

2.1 Introduction

The aftermath of the Great Recession brought the question of financial sector taxation to the forefront of policy discussion [European Commission (2013); Office (2013)], at the same time that academic debate on the welfare implications of rapidly growing high-frequency trading and derivative contracts spiked (Hendershott et al. (2011); Weill et al. (2012); Biais et al. (2013)). However, both empirical and theoretical understanding of the welfare implications of financial transaction taxes (FTTs) - one of the prominent instruments highlighted in recent years - is limited, especially when taking into consideration the complexity and interconnection of the underlying markets. Generally, the debate over FTTs versus alternative tax instruments (or no taxation at all) distinguishes between revenue and efficiency considerations, but few studies actually merge the two types of concerns. This paper fills in some of that gap by allowing for both revenue-raising and Pigouvian concerns to be potentially addressed by FTTs, enabling a more comprehensive analysis of their optimality. In doing so, I aim at contributing to our understanding of how traditional optimal commodity tax formulas can be derived from a micro-founded model of portfolio allocation, and how they should be modified to take into account the distinctive characteristics of capital asset trading. I compare these formulas to those found in the traditional commodity taxation literature with heterogeneous agents (starting with Diamond and Mirrlees (1971b)), where in contrast to the present setting, there
are no untaxed rents. In addition, I address some of the key welfare implications of these taxes from a revenue-raising perspective. Under certain plausible conditions over the redistribution of government revenues, I find a linear FTT may in fact induce first-order losses due to the distortion of the risk-sharing function of asset trading. This implication differs importantly from other literature on the role of taxation under uncertainty, such as Domar and Musgrave (1944); Gordon (1985); Kaplow (1994), and is especially closely related to Varian (1980) (though with the opposite result), in that redistributive taxation may in fact decrease social insurance.

In particular, I develop sufficient statistic formulas for optimal FTTs under an intertemporal model of portfolio selection by heterogeneous investors based on the baseline model of Dávila (2013), who studies the welfare impact of introducing a linear FTT under a model of trading with belief disagreement. Under his baseline model, trading is motivated by either different hedging needs, risk aversion, initial asset holdings (fundamental trading), or beliefs (non-fundamental, suboptimal trading). Assuming there is no redistribution objective and that optimists are mostly buyers and pessimists mostly sellers, Dávila obtains a closed formula solution for the optimal tax where the reduction in distortion induced by belief disagreement is traded off against the loss in fundamental trading arising from the introduction of the tax. Although a pivotal contribution to our understanding of the welfare consequences of an FTT, the formulas for the optimal linear tax presented in that paper are limited in that the only objective of the tax under Dávila’s framework is to serve as a corrective tax for excessive trading caused by divergent beliefs about asset returns - there is no consideration of the need for covering existing VAT loopholes, targeting financial sector rents, or any other revenue-raising objectives which have been called for in the policy sphere. This paper adds such an objective to a simplified dynamic extension of his CARA-Normal model with consumption only of terminal wealth. Furthermore, I explicitly consider retiming responses in transaction realizations and tax arbitrage in the form of shifting across trading platforms by allowing investors to choose trading in two different markets, and am able to match such parameters to empirically measured elasticities from chapter 1, thus informing optimal FTT policy rates. In the case of a linear tax with a single market, the simplest model in the present paper suggests a cash equity transaction tax of 0.67% on the notional value of transactions purely to maximize revenue.

This paper contributes to the broader literature on the welfare effects of transaction taxes in a variety of asset markets. There is an emerging literature examining the response of the housing market to transaction taxes (Kleven and Best (2015); Fu et al. (2013)). Kleven and Best (2015) have similar parallels to the results in the present paper in that they also find the introduction of a transaction tax induces not only an inaction region (at the extensive margin - some investors decide not to trade
at all), but also an anticipation of transaction realizations to the period immediately before the implementation of the tax (assuming full information about its introduction). On financial asset transactions taxation, in addition to Subrahmanyam (1998); Dow and Rahi (2000); Dávila (2013), more recently Dang and Morath (2015) have compared the welfare implications (in terms of losses of gains from trade) from distortions to investors’ incentives to endogenously produce private information caused by either a capital gains tax or a transaction tax in a static decentralized asset trading framework. In a one-shot take-it-or-leave-it bargaining game, the authors show that an increase of a transaction tax can cause adverse selection and lower probability of trade, with the opposite being true of capital gains taxes\(^1\). However, this distinction does not necessarily generalize to a multi-period model such as the one discussed in this paper, where the effects of future transaction taxes are conceptually similar to those of capital gains taxes. There is also a related and more established literature on transaction costs (Amihud and Mendelson (1992); Constantinides (1986); Vayanos (1998)). In addition, this paper draws heavily from the canonical theoretical finance literature on portfolio selection (Mossin (1968); Samuelson (1969); Lintner (1969); Ingersoll (1987)).

### 2.2 Baseline model

I present a three period setting based on Dávila (2013)’s static model. The motivation for a three period extension, discussed in section 2.2, is to mimic an untaxed trading period where investors can fully anticipate future taxes. This setup allows us to analyze the comparative statics of both the implementation and anticipation of a tax on equilibrium trading volumes and market prices.

Investors have CARA utility and face heterogeneous endowment shocks\(^2\). This is the simplest version of a dynamic model that generates endogenous trading in consecutive periods and allows for a straightforward introduction of a Pigouvian correction motivation for an FTT if we allow investors to disagree about expected returns of a single risky asset. The only policy instrument available at this stage is a

\(^1\)In their model, without taxes, private information acquisition causes an endogenous lemons problem - informed responders are more likely to trade the more the known asset payoff is in their favor, so the (uninformed) proposer would have preferred not to trade ex-post. With a capital gains tax, this lemons problem is mitigated because informed trade is less likely to occur. In contrast, with a sales (transaction) tax, the lemons problem is aggravated in that there are more states of the world with information acquisition, and less trade in equilibrium.

\(^2\)In contrast to Dávila (2013), I assume risk aversion and initial holdings of the risk asset are the same for all investors, and thus there is no endogenous trading generated by differences in either of these parameters.
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

linear financial transaction tax $\tau$ paid on the nominal value of any purchase or sale incurred.

**Investor characteristics, market structure and beliefs**

Time is discrete; there are three dates $t = \{1, 2, 3\}$, and a unit measure of investors. The latter are indexed by $i$ and are distributed according to probability distribution $F$. Investors choose a portfolio allocation at $t = 1, 2$ to maximize terminal wealth at $t = 3$. Investors have CARA utility ($U_i(C_{3i}) = -e^{-AC_{3i}}$) with coefficient of absolute risk aversion $A > 0$, which is constant among investors.

There is a riskless asset denoted $Y$ with infinitely elastic supply and paying interest rate $r=1$, and a single risky asset, $X$, with exogenously fixed supply $Q \geq 0$ in all periods. Initial holdings of the risky asset before $t = 1$, given by $X_0 > 0$, are the same across all investors. Dividends on the risky asset $D$ are realized in periods $t = 2, 3$, with a stationary distribution. Investors can borrow and short sell freely.

Every investor has a stochastic endowment shock at $t = 2, 3$ denoted $Z_{2i}$ and $Z_{3i}$, respectively. It is normally distributed, serially uncorrelated and potentially correlated with dividends on the risky asset $D$. This heterogeneity in hedging needs is the key fundamental driver of trading in periods $t = 1, 2$ in this model. Without loss of generality, I assume $E[Z_{ti}] - \frac{1}{2} Var[Z_{ti}] = 0$ and normalize the initial endowment $Z_{1i}$ to zero for all investors. Therefore, endogenous trading is essentially generated in this model by one “fundamental” motive - different hedging needs captured by $Cov_i[Z_{ti}, D]^4$.

Finally, a linear transaction tax $\tau_i$ is due over the net nominal amount of each period’s purchases/sales of the risky asset. In other words, both buyers and sellers are liable for the tax (making $|\Delta X_{ti}| \equiv |X_{ti} - X_{t-1,i}|$ the relevant tax base). Let $T_{ti} = \tau P_t |\Delta X_{ti}|$ be each individual’s rebate$^5$ - equal to her tax liability.

Figure 2.1 depicts the timeline of investors’ choices and the realization of shocks.

---

$^3$In contrast to Dávila (2013), there is only a portfolio selection decision in $t = 1, 2$ and no consumption-saving choice. This difference does not materially affect the economic intuition of the results below, and simplifies the algebra in a dynamic setting.

$^4$A “non-fundamental” negative externality generating motive captured by different beliefs over the returns of the risky asset $E_i[D]$ will be added in section .2 for comparison with the exclusively Pigouvian-motivated optimal tax results of Dávila (2013).

$^5$This rebate will be relaxed later once we take into account potentially revenue-raising motives for the introduction of an FTT. Note CARA utility alone would be enough to ensure the absence of income effects. In other words, an individual’s investment in risky assets is independent from her wealth. Therefore, we will be able to focus on substitution effects of changes in tax rates, even without a tax rebate - such as in the case of sole maximization of government revenue.
• Investors start with stock of risky asset $X_0$.
• Choose portfolio allocation $\{X_{1i}, Y_{1i}\}$ and trade.
• Transaction tax $\tau_1$ levied (and possibly rebated).

• Endowment shocks $E_{2i}$ realized and dividends $D$ paid out.
• Choose portfolio allocation $\{X_{2i}, Y_{2i}\}$ and trade.
• Transaction tax $\tau_2$ levied (and possibly rebated).

• Endowment shocks $E_{3i}$ realized and dividends $D$ paid out.
• Consume terminal wealth $W_{3i}$

Figure 2.1: Timeline of investors’ actions in the baseline model

**Investors’ Optimization Problem**

In what follows, I solve for each investor’s optimization problem recursively, taking prices as given in each period. Note we can re-express each step of the dynamic programming problem as a Markowitz mean-variance problem given independence of stochastic variables $D$ and $E_{ti}$ across periods.

Investors are subject to the following budget constraints (setting $P_3 = 1^6$):

$$C_{3i} = Z_{3i} + (1 + D) X_{2i} + (1 + r) Y_{2i}$$

$$Y_{2i} = Z_{2i} + D \cdot X_{1i} + Y_{1i} (1 + r) - (1 + \tau) P_2 |X_{2i} - X_{1i}| + T_{2i}$$

$$Y_{1i} = - (1 + \tau) P_1 |X_{1i} - X_0| + T_{1i}$$

The corresponding derived utility of wealth $W_{3i}$ (in risky and riskless assets) is

$$V [W_{3i}; t] \equiv \max_{X_{ti}, Y_{ti}} \mathbb{E}_t [U_i(C_{3i})] \text{ for } t = 1, 2$$

$$V [W_{3i}; 3] \equiv U_i[C_{3i}]$$

---

6 Without loss of generality, $P_3 = 1$ represents the value of risky assets on liquidation.
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

Assuming $E[Z_{ti}]$ and $E[D]$ are independent across periods, we can re-write (1) and (2) as

$$V^*[W_{3i}; t] \equiv \max_{X_{ti}, Y_{ti}} \left[ E_t [C_{3i}] - \frac{A}{2} \text{Var} [C_{3i}] \right] \text{ for } t = 1, 2$$

$$V^*[W_{3i}; 3] \equiv C_{3i} - \frac{A}{2} \text{Var} [C_{3i}]$$

Lemma 1. Investor demand for the risky asset in periods $t = 1, 2$ is a function of exogenously given prices, expected dividend payouts, idiosyncratic covariance of endowment shocks and dividend payouts, as well as contemporaneous and future transaction taxes. In particular, we have

$$X^*_{2i} = \frac{-2 (1 + \tau_2 \cdot \text{sgn} \Delta X_{2i}) P_2 + E_2 (1 + D) - A \text{Cov}_i (Z_{3i}, D)}{A \text{Var} [D]}$$

and

$$X^*_{1i} = \frac{-(1 + \tau_1 \cdot \text{sgn} \Delta X_{1i}) P_1 + E_1 [D + (1 + \tau_2 \cdot \text{sgn} \Delta X_{2i}) P_2] - 2 A \text{Cov}_i [Z_{2i}, D]}{2 A \text{Var} [D]}$$

where $\text{sgn} \Delta X_{ti} = +(-)$ if $X_{ti} - X_{t-1,i} > (<)0$.

Lemma 1 follows by replacing $r = 1$, and taking $X_{1i}$ and prices as given. It is formally derived in section .2. Note that the first-order conditions underlying these demand functions only corresponds to actual equilibrium solutions if we know both $\text{sgn} \Delta X_{1i}$ and $\text{sgn} \Delta X_{2i}$. In comparison to an equilibrium without transaction taxes, we see that for any strictly positive asset prices, taxes $\tau$ lower net asset demand for contemporaneous buyers and raise it for sellers, thus decreasing the overall equilibrium transaction volume for any given level of prices.

Equilibrium prices

For simplicity, aggregate price cum dividend expectations are assumed to be correct on average (i.e., $\int_{i \in T} E_{ti} [D_{t+1}] = \overline{D} (i)$ and $\int_{i \in T} E_{ti} [(1 + \tau \cdot \text{sgn} \Delta X_{t+1,i}) P_{t+1}] = P_{t+1} (1 + \tau \cdot \int_{i \in T} \text{sgn} \Delta X_{t+1,i} \text{d}F (i))^7$).

Lemma 2. Given the allocations derived above, market clearing conditions\textsuperscript{8} give us

\textsuperscript{7}I enforce this condition to ensure I can solve for actual equilibrium prices using demand functions which rely on their expected, rather than realized value. This condition would not be necessary in a static version of the model, since demand there is only dependent on contemporaneous prices.

\textsuperscript{8}For the full derivation, please refer to section .2.
Equilibrium without taxes and retiming with a tax wedge

In this section I introduce a tax wedge, defined as the difference between transaction tax rates in periods 1 and 2. Intuitively, this is meant to capture the incentives observed in practice, where there is typically an untaxed trading period when a future tax is announced; full information about future taxes will affect behavior today, especially in the presence of a non-zero tax wedge. In addition, a zero tax wedge between periods 1 and 2 with a strictly positive tax rate (\(\tau_1 = \tau_2 > 0\)) is still a useful benchmark for a “steady-state” taxed equilibrium (where being taxed in every period in fact attenuates the overall response of trading volume), which I contrast to the untaxed equilibrium described in lemma 3.

**Lemma 3.** If \(\tau=0\) for all periods, then the equilibrium allocation and prices above simplify to:

\[
X^*_{1i} = \frac{-P_1 + E_1[D + P_2] - 2ACov_i(Z_{2i}, D)}{2\text{Var}[D]}
\]

\[
X^*_{2i} = \frac{-2P_2 + E_2(1 + D) - ACov_i(Z_{3i}, D)}{\text{Var}[D]}
\]

\[
P_1 = \int_{i \in T} \frac{1 + \bar{D} - 4ACov_i(Z_{2i}, D) - \text{ACov}_i(Z_{3i}, D) - X_0 \cdot 5\text{Var}[D]}{2} dF(i)
\]

\[
P_2 = \int_{i \in T} \frac{1 + \bar{D} - \frac{3}{5}ACov_i(Z_{3i}, D) - X_0 \cdot \text{Var}[D]}{2} dF(i)
\]
This follows directly by setting $\tau_1$ and $\tau_2=0$ in lemmas 1 and 2.

**Proposition 1.** Other things equal, the introduction of a tax in creates a contemporaneous trading inaction region - a set of investor asset demands for which it is optimal not to trade - monotonically increasing in the size of the tax.

Formally, in period 1 there is an inaction region defined by

$$\frac{-(1 - \tau_1)P_1 + \zeta_1}{v_1} > X_0 > \frac{-(1 + \tau_1)P_1 + \zeta_1}{v_1}$$

where $\zeta_1 = \mathbb{E}_1[D + (1 + \tau_2 \cdot \text{sgn}\Delta X_{2i})P_2] - 2A\text{Cov}_i[Z_{2i}, D]$, and $v_1 = 2A\text{Var}[D]$.

Similarly, in period 2 the inaction region is defined by

$$\frac{-2(1 - \tau_2)P_2 + \zeta_2}{v_2} > X^*_{1i} > \frac{-2(1 + \tau_2)P_2 + \zeta_2}{v_2}$$

where $\zeta_2 = \mathbb{E}_2(1 + D) - A\text{Cov}_i[Z_{3i}, D]$ and $v_2 = A\text{Var}[D]$. As with $\tau_1$, the introduction of $\tau_2$ generates a trading inaction region monotonically increasing in the size of the contemporaneous tax. The straightforward derivation of these inaction regions by defining the sets of net buyers and sellers in each period is described in section 2.

In turn, the effect of introducing a tax in period 2 on period 1 trading depends on the aggregate net market demand for risky assets in period 2. If a trader is a net buyer in period 2, then $\tau_2$ shifts the inaction region in period 1 upwards (on the $\text{Cov}_i[Z_{2i}, D]$ line), so traders are more likely to buy in period 1, and less likely to sell; on the other hand, if trader $i$ is a net seller in period 2, then $\tau_2$ shifts the inaction region in period 1 downwards, so traders are more likely to sell and less likely to buy in period 1. In short, a tax in the second period attenuates the size of the inaction region generated by the tax in period 1, all the while generating its own inaction region in the second period. The retiming of transactions across periods is optimal irrespective of whether there is a wedge between $\tau_1$ and $\tau_2$, as long as $\tau_2 > 0$.

**Proposition 2.** The introduction of a tax in period 2 ($\tau_2$) shifts the optimal pattern of trading towards period 1 (relative to an untaxed equilibrium). Specifically, $\tau_2$ increases (decreases) net asset demand in period 1 by $\frac{\tau_2 P_2}{2A\text{Var}[D]}$ if the investor is a net buyer (seller) in period 2.

---

9In addition, in this section I am assuming for illustration that there are no short sales, so that $X^*_{1i} \geq 0, \forall i$.

10Intuitively, due to the concavity of the utility function, the marginal cost of a deviation from untaxed optimum for a single control variable is higher than those of smaller adjustments in multiple variables.
In other words, there is anticipation of trading due to the new tax. Figure (2.2) illustrates this for period 1 trading motivated solely by different initial endowments, and period 2 trading motivated solely by different hedging needs, where by construction period 1 buyers are also period 2 buyers and likewise for sellers.

The effect of a tax on equilibrium prices depends on the net aggregate market demand for risky assets in each respective period, as in Dávila (2013). Specifically, if net market demand is positive in period $t$, introducing a tax $\tau_t$ unambiguously lowers $P_t$, and vice-versa if net market demand is negative. In this framework, $P_t$ is not directly affected by the tax in other periods ($\tau_s$, where $s \neq t$), but is indirectly affected by a possible change in the direction of net market demand at $t$ ($\int_{i \in T} \text{sgn}\Delta X_{it}dF(i)$).

In Appendix section .2, I contrast this result with that observed in the case of dividend taxes, and show that the source of the seeming independence of prices from non-contemporaneous taxes arises from canceling intertemporal substitution effects (an artifice of the distributional assumptions made in the current framework).

Optimal tax policy

Welfare effect of a revenue-raising FTT

In this section I conduct the welfare analysis of the introduction of a revenue-raising linear FTT first with and then without individualized tax rebates\(^{11}\). In both cases, the social planner chooses the tax rate in effect in the second period (in what follows, $\tau \equiv \tau_2$), and for now we set $\tau_1 = 0$\(^{12}\). Social welfare $V$ is expressed as the sum of the indirect utility for every investor $i$, under the distribution of returns used by the planner (which are assumed to be the same for all investors as well)

$$V(\tau) = \int \lambda_i V_i dF(i)$$

where $\lambda_i > 0$ is the welfare weight corresponding to each investor and

$$V_i \equiv \mathbb{E}[U_i(W_{3i})] = -e^{-A\hat{V}_i} \text{ with } \hat{V}_i \equiv \mathbb{E}[W_{3i}(X_{1i}, X_{2i}, P_1, P_2)] - \frac{A}{2} \text{Var}[W_{3i}(X_{1i}, X_{2i}, P_1, P_2)]$$

$\hat{V}_i$ is thus the individual certainty equivalent from the planner’s perspective.

I first analyze the deadweight loss induced if all government revenues are redistributed to taxpayers to exactly offset their tax liability (so that there is no income effect irrespective of whether or not one uses CARA utility).

\(^{11}\)I defer the dynamic extension of the welfare analysis of a Pigouvian tax à la Dávila (2013) to the appendix (section .2).

\(^{12}\)And so $T_{1i} = 0$. 

CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

Substituting for \( W_{3i} \) explicitly, and using the fact that the planner takes into account the individualized rebate of tax receipts to traders, we can re-express \( \hat{V}_i \) as

\[
\hat{V}_i = \mathbb{E} \left[ (1 + D) X_{2i} + 2 \cdot \{ [D + P_2] X_{1i} + 2 \{ P_1 X_0 - P_1 X_{1i} \} - P_2 X_{2i} \} \right] - \frac{A}{2} \left\{ (X_{2i}^2 + 4X_{1i}^2) \text{Var}(D) + 2X_{2i} \text{Cov}_i(Z_{3i}, D) + 8X_{1i} \text{Cov}_i(Z_{2i}, D) \right\}
\]

where \( X_{2i} \) and \( X_{1i} \) are chosen optimally by traders in each period as derived above.

The marginal effect of a tax change on the indirect utility of individual investors \( \frac{dV_i}{d\tau} \) equals

\[
\frac{dV_i}{d\tau} = A e^{-\hat{A}i} \frac{d\hat{V}_i}{d\tau} = \mathbb{E} \left[ U'_i(W_{3i}) \right] \frac{d\hat{V}_i}{d\tau}
\]

In turn, the marginal change in the certainty equivalent can be expressed as

\[
\frac{d\hat{V}_i}{d\tau} = 2\tau \cdot \text{sgn} \Delta X_{2i} P_2 \left( \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right) - 2P_1 \frac{dX_{1i}}{d\tau} - 2\Delta X_{2i} \frac{dP_2}{d\tau} - 4\Delta X_{1i} \frac{dP_1}{d\tau}
\]

Thus the marginal change in social welfare from the introduction of a financial transaction tax in the second trading period is

\[
\left. \frac{dV}{d\tau} \right|_{\tau = \hat{\tau}} = \int_{\lambda_i \mathbb{E} \left[ U'_i(W_{3i}) \right]} \left[ 2\tau \cdot \text{sgn} \Delta X_{2i} P_2 \left( \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right) - 2P_1 \frac{dX_{1i}}{d\tau} \right] dF(i)
\]

\[
- \int \lambda_i \mathbb{E} \left[ U'_i(W_{3i}) \right] \left[ 2\Delta X_{2i} \frac{dP_2}{d\tau} - 4\Delta X_{1i} \frac{dP_1}{d\tau} \right] dF(i) \tag{2.5}
\]

The tax affects social welfare by distorting optimal trade patterns (driven by different risk-aversion, initial endowments, or hedging needs), and intertemporal terms-of-trade. Assuming i) no redistribution \( (\Rightarrow \lambda_i \mathbb{E} \left[ U'_i(W_{3i}) \right] \text{ constant, } \forall i) \), and using market clearing\(^\text{13}\), expression (2.5) becomes:

\[
\left. \frac{dV}{d\tau} \right|_{\tau = \hat{\tau}} = \int_{\lambda_i} \left[ 2\tau \cdot \text{sgn} \Delta X_{2i} P_2 \left( \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right) \right] dF(i)
\]

\(^{13}\int \Delta X_{1i} dF(i) = 0 \text{ and } \int \frac{dX_{2i}}{d\tau} dF(i) = 0.\)
In the present setting, the deadweight loss from the introduction of a small tax can be approximated (in a Harberger (1964) sense). Concretely, adding the marginal change in welfare divided by investors’ marginal utility across the continuum of investors and using the market-clearing condition at each period \( \int \Delta X_i dF (i) = 0 \) and \( \int_{i \in T} sgn \Delta X_i \frac{dX_i}{d\tau} dF (i) = 2 \int_{i \in B} \frac{dX_i}{d\tau} dF (i) \), (2.5) yields:

\[
\int d\hat{V}_i dF (i) = 4\tau \left[ P_2 \int_{i \in B} \left( \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right) dF (i) (d\tau) \right]
\]

where \( B \) represents the set of buyers in the market. Locally around \( \tau = 0 \), equation (2.6) = 0, so there is no first-order deadweight loss, but there is a second-order loss associated with the distortion of allocations of the risky asset across periods.

A second-order Taylor expansion of this expression around \( \tau = 0 \) gives us

\[
\int d\hat{V}_i |_{\tau=0} dF (i) \approx 2 \left[ P_2 \int_{i \in T} sgn \Delta X_{2i} \tau \left( \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right) \big|_{\tau=0} dF (i) (d\tau) \right] + 2 \left[ P_2 \int_{i \in T} sgn \Delta X_{2i} \left( \frac{d^2 X_{2i}}{d\tau^2} - \frac{d^2 X_{1i}}{d\tau^2} \right) \big|_{\tau=0} dF (i) (d\tau^2) \right] + 2 \left[ \frac{dP_2}{d\tau} \int_{i \in T} sgn \Delta X_{2i} \tau \left( \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right) \big|_{\tau=0} dF (i) (d\tau^2) \right] + 4\tau^2 \left[ \int_{i \in B} P_2 \left( \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right) \big|_{\tau=0} dF (i) \right] < 0
\]

The deadweight loss associated with a small tax in the present dynamic setting with individualized rebates is proportional to the square of the tax, in line with the classic Harberger (1964) results.\(^{14}\)

Consider instead the case of a revenue-raising FTT in which there are no individualized tax rebates (either by there being no rebate at all \( T_{2i} = 0, \forall i \), or there being only lump-sum transfers independent from the original individual tax liability \( T_{2i} = \bar{T}_2, \forall i \)). Social welfare is defined in the same way as in the beginning of this section.

\(^{14}\)A sufficient and necessary condition for the excess burden thus measured to be negative is that \( \int_{i \in B} \frac{dX_i}{d\tau} \big|_{\tau=0} dF (i) < \int_{i \in B} \frac{dX_i}{d\tau} \big|_{\tau=0} dF (i) \) (in words, that the overall trading volume increase in period 1 be greater than that of period 2; this is always true whenever there is a net decline in trading volume in period 2).
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

The individual certainty equivalent can be expressed then as

\[ \hat{V}_i = \mathbb{E}[(1 + D) X_{2i} + 2 \cdot \{ [D + (1 + \tau \cdot sgn \Delta X_{2i}) P_2 X_{1i} + 2 \{ P_1 X_0 - P_1 X_{1i} \}] ]
- 2 (1 + \tau \cdot sgn \Delta X_{2i}) P_2 X_{2i}
- \frac{A}{2} \{ (X_{2i}^2 + 4X_{1i}^2) \text{Var}(D) + 2X_{2i} \text{Cov}(Z_{3i}, D) + 8X_{1i} \text{Cov}(Z_{2i}, D) \}
\]

In turn, the marginal change in the certainty equivalent can be expressed as

\[ \frac{d\hat{V}_i}{d\tau} = -2P_1 \frac{dX_{1i}}{d\tau} - 2 (1 + \tau \cdot sgn \Delta X_{2i}) \frac{dP_2}{d\tau} - 4\Delta X_{1i} \frac{dP_1}{d\tau} - 2sgn \Delta X_{2i} P_2 [\Delta X_{2i}] \]

Thus the marginal change in social welfare from the introduction of a financial transaction tax in the second trading period is

\[ \frac{dV}{d\tau} \bigg|_{\tau=\tilde{\tau}} = \int_{i \in T} \lambda_i \mathbb{E} \left[ U_i' (W_{3i}) \right] \frac{dX_{1i}}{d\tau} dF(i)
- \int_{i \in T} \lambda_i \mathbb{E} \left[ U_i' (W_{3i}) \right] 2 (1 + \tilde{\tau} \cdot sgn \Delta X_{2i}) \frac{dP_2}{d\tau} - 4\Delta X_{1i} \frac{dP_1}{d\tau} dF(i)
- \int_{i \in T} \lambda_i \mathbb{E} \left[ U_i' (W_{3i}) \right] 2sgn \Delta X_{2i} P_2 [\Delta X_{2i}] dF(i) \quad (2.7) \]

Note the last term in (2.7) represents a distortion of the risk-sharing provided by asset trading in the model. With no individualized tax rebates, the mechanism is the opposite from insurance through taxation under uncertainty as described by Kaplow (1994) or Domar and Musgrave (1944). For an FTT, the government is effectively taxing the holdings of the only instruments available for self-insurance by agents (thereby worsening risk-sharing), rather than taxing the source of idiosyncratic risk in the model\textsuperscript{15}. Deadweight loss is thus positive (in other words, there is a net loss to social welfare after taking into account government revenues).

\textsuperscript{15}In contrast, a terminal dividend tax for example would generate negative deadweight loss (or a net gain to society) by reducing idiosyncratic risk exposure (intuitively, the smaller the dividend risk, the smaller its covariance risk with my endowment shocks too).
Assuming constant $\lambda_i \mathbb{E} \left[ U_i' (W_{3i}) \right], \forall i$, and using market clearing\(^{16}\), expression (2.7) becomes:

$$
\frac{dV}{d\tau} \bigg|_{\tau = \tilde{\tau}} = -4\tilde{\tau} \frac{dP_2}{d\tau} \int_{i \in \mathcal{B}} \Delta X_{2i} dF(i) - 4P_2 \int_{i \in \mathcal{B}} \Delta X_{2i} dF(i) \quad (2.8)
$$

This is simplified locally around $\tau = 0$ to

$$
\frac{dV}{d\tau} \bigg|_{\tau = 0} = -4P_2 \int_{i \in \mathcal{B}} \Delta X_{2i} \big|_{\tau = 0} dF(i) \quad (2.9)
$$

**Proposition 3.** With no Pigouvian motives, a linear FTT without individualized tax rebates induces a first-order loss to investors.

The government receives $R = 2P_2 \int_{i \in \mathcal{B}} \Delta X_{2i} \big|_{\tau = 0} dF(i)$ in tax payments, so deadweight loss is strictly positive. Distortions to first period trading and prices cancel out between investors. However, there is a second-order distortion of second period prices; the sign of this term depends on the sign of $\frac{dP_2}{d\tau}$. If $\frac{dP_2}{d\tau} < 0$, this second-order term is positive, and the tax wedge is actually declining as $\tau$ increases, attenuating the first-order deadweight loss. Intuitively, lower prices are welfare-improving because they reduce the tax liability for any given tax rate $\tau$. In contrast to the case with individualized tax rebates (as well as the setup in Dávila (2013)), there are no second-order losses corresponding to fundamental distortions of allocations ($\frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau}$)\(^{17}\).

Adding the marginal change in welfare divided by investors’ marginal utility across the continuum of investors and using the market-clearing condition at each period ($\int \Delta X_{ti} dF(i) = 0$ and $\int_{i \in \mathcal{T}} \text{sgn} \Delta X_{ti} \frac{dX_{ti}}{d\tau} dF(i) = 2 \int_{i \in \mathcal{B}} \frac{dX_{ti}}{d\tau} dF(i)$), (2.8) simplifies to

$$
\int d\hat{V}_i dF(i) = -4\tilde{\tau} \left[ \frac{dP_2}{d\tau} \int_{i \in \mathcal{B}} \Delta X_{2i} dF(i) \right] - 4P_2 \int_{i \in \mathcal{B}} \Delta X_{2i} dF(i) \quad (2.10)
$$

A second-order Taylor expansion of this expression around $\tau = 0$ gives us

\(^{16}\int \Delta X_{ti} dF(i) = 0, \int \frac{dX_{ti}}{d\tau} dF(i) = 0, \text{ and } \int_{i \in \mathcal{T}} \text{sgn} \Delta X_{ti} [\Delta X_{ti}] dF(i) = 2 \int_{i \in \mathcal{B}} [\Delta X_{ti}] dF(i).\)

\(^{17}\)This follows from the envelope theorem.
\[
\int d\hat{V}_i|_{\tau=0}dF(i) \approx -4\frac{dP_2}{d\tau} \int_{i \in B} \tau \cdot \Delta X_{2i}|_{\tau=0}dF(i)(d\tau) - 4P_2 \int_{i \in B} \Delta X_{2i}|_{\tau=0}dF(i)(d\tau) - 2\frac{dP_2}{d\tau} \int_{i \in B} \Delta X_{2i}|_{\tau=0}dF(i)(d\tau^2) - 2\frac{d^2P_2}{d\tau^2} \int_{i \in B} \tau \Delta X_{2i}|_{\tau=0}dF(i)(d\tau^2) = -4\tau P_2 \int_{i \in B} \Delta X_{2i}|_{\tau=0}dF(i) - 2\tau^2 \frac{dP_2}{d\tau} \int_{i \in B} \Delta X_{2i}|_{\tau=0}dF(i)
\]

Taking into account government revenues collected, the change in welfare for society associated with a small tax in the present setting is

\[ -2 \left[ \tau P_2 + \tau^2 \frac{dP_2}{d\tau} \right] \int_{i \in B} \Delta X_{2i}|_{\tau=0}dF(i). \]

The first term is negative as long as prices are non-negative; the second term is positive if \( \frac{dP_2}{d\tau} < 0 \), which in the model is an equilibrium result if there is net buying pressure in the market \( (\int_{i \in T} \text{sgn} \Delta X_{2i}dF(i) > 0) \).

**Corollary 1.** The deadweight loss from the introduction of a very small tax in period 2 is negative iff \( \tau P_2 > \tau^2 \left| \frac{dP_2}{d\tau} \right| \Leftrightarrow \frac{P_2}{\frac{dP_2}{d\tau}} > \tau \).

This follows from the preceding paragraph. Intuitively, if the price decline in response to a change in \( \tau \) is sufficiently large relative to its pre-tax equilibrium value, it may compensate taxpayers more than enough for their new tax liability. In theory, it is possible for \( \frac{dP_2}{d\tau} > 0 \) if there is net selling pressure in the market \( (\int_{i \in T} \text{sgn} \Delta X_{2i}dF (i) < 0) \), in which case there is an unambiguous marginal welfare loss for any \( \tau > 0 \) locally around zero. Therefore, there is a first-order loss and a second-order gain or loss (depending on the sign of \( \frac{dP_2}{d\tau} \)) from the introduction of a linear FTT with no individualized tax rebates. Figure 2.3 illustrates this net effect for a small tax both with and without individualized tax rebates.

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18 Empirical estimates in the literature suggest that is the case.
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

Revenue maximizing tax

The revenue-maximizing linear tax rate (without individualized tax rebates, $T_{2i} = 0, \forall i$) solves the following problem

$$\max_{\tau_2} R = \tau_2 \cdot P_2 \int |\Delta X_{2i}| dF(i)$$

where $R$ is total government revenue.

As before, let $\tau \equiv \tau_2$ in what follows. Then $\tau_{RM}^*$ maximizing tax revenue is such that

$$\frac{dR}{d\tau} = 0 \Rightarrow P_2 \int_{i \in T} sgn(\Delta X_{2i}) \Delta X_{2i} dF(i) + \int_{i \in T} sgn(\Delta X_{2i}) \tau P_2 \left[ \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right] dF(i) + \int_{i \in T} sgn(\Delta X_{2i}) \frac{dP_2}{d\tau} \cdot \Delta X_{2i} dF(i) = 0$$

$$\Rightarrow 2P_2 \int_{i \in B} \Delta X_{2i} dF(i) + 2\tau P_2 \int_{i \in B} \left[ \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right] dF(i) + 2\frac{dP_2}{d\tau} \cdot \int_{i \in B} \Delta X_{2i} dF(i) = 0$$

$$\Rightarrow \tau_{RM}^* = -\left[ \frac{dP_2}{d\tau} \cdot \int_{i \in B} \Delta X_{2i} dF(i) + P_2 \int_{i \in B} \left[ \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right] dF(i) \right]$$

(2.11)

where I use $\int_{i \in T} sgn(\Delta X_{2i}) \frac{dX_{2i}}{d\tau} dF(i) = 2 \int_{i \in B} \frac{dX_{2i}}{d\tau} dF(i)$ and $\int_{i \in T} sgn(\Delta X_{1i}) \Delta X_{1i} dF(i) = 2 \int_{i \in B} \Delta X_{1i} dF(i)$ in the third line. Note $\frac{dP_2}{d\tau}$ can be either positive or negative (depending on $\int_{i \in T} sgn(\Delta X_{2i}) dF(i) > (\leq) 0$). In addition, recall that $\int_{i \in B} \frac{dX_{2i}}{d\tau} dF(i) < 0$ and $\int_{i \in B} \frac{dX_{1i}}{d\tau} dF(i) > 0$ (net volume decreases in the second period and increases in the first as a consequence of the tax).

**Proposition 4.** Let $\eta \equiv \int_{i \in T} \frac{dP_2/(1-\tau)}{P_2/(1-\tau)} dF(i)$ and $\epsilon = \int_{i \in T} \frac{dX_{2i}/(1-\tau)}{\Delta X_{2i}/(1-\tau)} dF(i)$. Then the revenue-maximizing second-period tax given by

$$\tau_{RM}^* = \frac{1}{1 + \eta + \epsilon}$$

is inversely proportional to the elasticity of the behavioral response.

Notice that $\int_{i \in B} \frac{dX}{d\tau} dF(i) = -\int_{i \in B} \frac{dX}{(1-\tau)} dF(i) = -\int_{i \in B} \frac{dX}{a(1-\tau)} dF(i)$, for a given $X$. Using this, proposition 4 follows by re-expressing $\tau_{RM}^*$ from equation 2.11 in
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

55
terms of empirically measurable parameters:

\[
\tau_{RM}^* = \frac{P_2 \cdot \int_{i \in B} \Delta X_{2i} dF(i)}{\frac{dP_2}{d(1-\tau)} \cdot \int_{i \in B} \Delta X_{2i} dF(i) + P_2 \cdot \int_{i \in B} \frac{d\Delta X_{2i}}{d(1-\tau)} dF(i)}
\]

\[
= \frac{[\eta \cdot \frac{P_2}{(1-\tau)} \cdot \int_{i \in B} \Delta X_{2i} dF(i) + P_2 \cdot \int_{i \in B} \epsilon \cdot \frac{\Delta X_{2i}}{(1-\tau)} dF(i)]}{(1-\tau) \cdot P_2 \cdot \int_{i \in B} \Delta X_{2i} dF(i)}
\]

\[
\Rightarrow \frac{\tau}{1-\tau} = \frac{1}{\eta + \epsilon}
\]

\[
\Rightarrow \tau_{RM}^* = \frac{1}{1 + \eta + \epsilon}
\]

which is evocative of standard revenue maximizing linear tax rate formulas in similar settings.

This formula is similar in simplicity to the revenue-maximizing top marginal income tax rate derived by Piketty et al. (2014). In this case (with a single asset type and no equity objectives) the relevant behavioral response encompasses both the valuation effect on \(P_2\) and changes in taxable trading volume in period 2. \(\eta\) can be measured as the price elasticity implied by a change in relative stock returns on tax announcement dates\(^{19}\). In addition, note \(\epsilon\) corresponds to the lock-in effect plus the temporary anticipation effect in this model (and thus both of those elasticities combined should be used); the static equivalent in Dávila (2013) would capture solely the lock-in effect. Finally, note that for purposes of estimating the revenue-maximizing tax rate (rather than evaluating welfare losses), the relevant elasticities should be computed not with respect to an increase in average transaction costs, but rather with respect to a change in the net-of-tax rate \((1-\tau)\) itself. As an illustration, using the estimates from the empirical part of this paper, \(\eta = \frac{-21.66\% - 6\%}{-0.2\%} = 108.3\), implying \(\tau_{RM}^* \approx 0.67\%,\) higher than currently imposed rates or most of those under discussion (\(\approx 0.1\%)^{20}.\) Figure 2.4 plots this relationship

\(^{19}\)Note the current model does not distinguish between announcement and implementation dates for purposes of parameter distortion, but insofar as \(P_2\) is perfectly anticipated, we can think of the effect of \(\tau\) as being fully anticipated as well.

\(^{20}\)The turnover elasticity here includes both the permanent lock-in effect and the temporary anticipation effect for non-high-frequency traders. Subtracting the latter from this measure \((\frac{-21.66\%}{-0.2\%} = 108.3),\) we would get a static revenue-maximizing \(\tau_{RM}^* \approx 0.84\%,\) still above current policy figures.
for a range of possible tax rates. In turn, the equivalent revenue-maximizing rate for a market of high-frequency traders would be even lower (at 0.022%), given the significantly higher lock-in elasticity of those agents.

### 2.3 Cross-platform trading

The framework presented above represents an isolated exchange market. In reality, financial assets trade on multiple venues (including exchanges in different countries, multilateral trading facilities, and dark/lit pools, among others). In this section I introduce a second platform competing over trading of the same risky assets. Namely, there is an over-the-counter (OTC) platform in which, in any given period, buyers can pay a discounted price \((1 - \mu) P_t\), and sellers receive a markup over the regular exchange price \((1 + \mu) P_t\). This concept is meant to capture some of the advantages of OTC or “upstairs market” participation relative to a regulated exchange (such as improved counterparty matching or bilaterally negotiated pricing for block trades). An equivalent way of framing this difference is thinking of trading in the exchange market as having pre-existing higher (non-tax) linear costs \(c = -\mu\) imposed on the notional value of transactions, absent in OTC. However, in order to participate in the OTC market, traders have to pay some fixed cost of entry \(\gamma\) in each period. In the absence of this fixed cost, OTC would always be strictly preferred to on-exchange trading, given the lower marginal transaction costs; the presence of the fixed cost however ensures only larger transaction sizes can benefit from a lower average transaction cost OTC. Thus, as I will show below, OTC will be dominated by larger trades than on-exchange. \(\mu\) and \(\gamma\) are exogenously given. I assume investor preferences and the distribution of stochastic state variables is the same as in the single market model above. In addition to introducing non-tax transaction costs to the exchange market, in what follows I allow a linear transaction tax rate to be different between OTC \((\tau_{OTC,t})\) and exchange trades \((\tau_{EX,t})\).

---

21 I let \(P_t\) be determined fully on the regulated exchange market, and taken as given by OTC traders. Market-clearing OTC can only be guaranteed in the presence of a third set of arbitrageurs/liquidity providers who, unlike other traders, do not face OTC fixed entry costs.

22 One can think of these costs as representing exchange fees or brokerage commissions.

23 \(\gamma\) is intended to capture the fact that often larger and better connected financial institutions have access to OTC markets.

24 So the tax rebate \(T_{hi}\) will also vary depending on where the investor chooses to trade.
Investors’ optimization problem

In each period, in addition to choosing the optimal holdings of the risky asset, investors face the choice of whether to trade OTC or on-exchange. In what follows, I describe the key elements of the investor problem and the equilibrium allocations. In period 3, as before, we can express the corresponding derived utility of wealth as

\[ V^* [W_{3i}; 3] \equiv C_{3i} - \frac{A}{2} \text{Var} [C_{3i}] \]

Then in period 2 the investor maximizes

\[ V^* [W_{3i}; 2] \equiv 1 V^*_{\text{OTC}} [W_{3i}; 2] + (1 - 1) V^*_{\text{EX}} [W_{3i}; 2] \]

where \( 1 = \begin{cases} 1 & \text{if the investor trades OTC} \\ 0 & \text{if the investor trades on-exchange} \end{cases} \) and \( V^*_{\text{EX}} [W_{3i}; 2] \) and \( V^*_{\text{OTC}} [W_{3i}; 2] \) are defined in Appendix section .2.

**Lemma 4.** Taking \( X_{1i} \) and prices as given, the FOCs in each market with respect to \( X_{2i} \) give us:

\[
-2\left(1+\tau_{\text{EX},2} \cdot \text{sgn} \Delta X_{2i}\right)P_2 + \mathbb{E}_2(1+D) - \text{ACov}_i(Z_{3i},D) \\
\quad \text{Var}[D] = X^*_{\text{EX},2i}
\]

\[
-2\left(1+\tau_{\text{OTC},2} \cdot \text{sgn} \Delta X_{2i}\right)(1-\mu \cdot \text{sgn} \Delta X_{2i})P_2 + \mathbb{E}_2(1+D) - \text{ACov}_i(Z_{3i},D) \\
\quad \text{Var}[D] = X^*_{\text{OTC},2i}
\]

**Proposition 5.** OTC is dominated by relatively larger transaction sizes.

Proposition 5 can be seen from setting both \( \tau_{\text{EX},2} = \tau_{\text{OTC},2} = 0 \), such that \( X^*_{\text{OTC},2i} > X^*_{\text{EX},2i} \) for buyers (and the opposite for sellers), irrespective of previous period holdings of the risky asset \( X_{1i} \).

Note as well that

\[
X^*_{\text{OTC},2i} + \frac{2\left[\left(1+\tau_{\text{OTC},2} \cdot \text{sgn} \Delta X_{2i}\right)(1-\mu \cdot \text{sgn} \Delta X_{2i}) - (1+\tau_{\text{EX},2} \cdot \text{sgn} \Delta X_{2i})\right]}{\text{Var}[D]} = X^*_{\text{EX},2i}
\]

\[25\text{For the full derivation, please refer to Appendix section .2.}
\[26\text{Since } \mu > 0.\]
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL
TRANSACTION TAXATION

where I impose \( \text{sgn}\Delta X_{2i} \) be the same OTC or on-exchange. For simplicity of notation, denote

\[
\alpha_2 \equiv \frac{2\beta_2}{A\text{Var}[D]}
\]

and

\[
\beta_2 \equiv [(1+\tau_{OTC,2}\cdot\text{sgn}\Delta X_{2i})(1-\mu\cdot\text{sgn}\Delta X_{2i})-(1+\tau_{EX,2}\cdot\text{sgn}\Delta X_{2i})]P_2
\]

\[
= [(\tau_{OTC,2}-\mu-\tau_{EX,2})\cdot\text{sgn}\Delta X_{2i}-\mu\tau_{OTC,2}]P_2
\]

Proposition 6. A net second period buyer will choose to trade OTC iff

\[
X^*_{EX,2i} \geq \frac{\alpha_2\cdot\left\{\frac{\tau_{OTC,2} - 2\tau_{EX,2}}{2}\right\}P_2 - \frac{\beta_2}{2}}{\mu(1+\tau_{OTC,2})P_2} + \frac{\gamma}{\mu} + X_1i \equiv Z_{2i}
\]

Therefore, for each individual there is a jump in the second period demand for holdings of the risky asset at \( Z_{2i} \). For a net seller, the inequality is simply reversed. In an equilibrium without transaction taxes in either market, the break-even point (2.12) for OTC participation simplifies to

\[
X^*_{EX,2i} \geq -\frac{[\mu P_2]^2}{A\text{Var}(D)} + \frac{\gamma}{\mu P_2} + X_1i
\]

Moving back to period 1, the investor solves

\[
V^*[W_{3i};1] \equiv I_{OTC}[W_{3i};1] + (1-I) V^*[W_{3i};1]
\]

Substituting the budget constraints faced in each market into (2.13) (as well as \( X^*_{2i} = X^*_{EX,2i} - \mathbb{1}_2 \alpha_2 \) and \( Y^*_{2i} \), where \( \mathbb{1}_2 = \begin{cases} 1 & \text{if } X^*_{EX,2i} \cdot \text{sgn} \Delta X_{2i} \geq Z_{2i} \\ 0 & \text{otherwise} \end{cases} \), we get the FOCs with respect to \( X_{1i} \):

\[
-2\left(1+\tau_{EX,1}\cdot\text{sgn}\Delta X_{1i}\right)P_1 + \mathbb{E}_1\left[D + (1+\tau_{EX,2}\cdot\text{sgn}\Delta X_{2i})P_2 + \mathbb{1}_2 \beta_2\right] - 2 A \cdot \text{Cov}[Z_{2i},D] = X^*_{EX,1i}
\]

\(^{27}\)Without loss of generality, I assume the investor will choose to trade on-exchange if indifferent (i.e., if \( X^*_{EX,2i} = Z_{2i} \)).
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

\[-2(1+\tau_{OTC,1}\cdot sgn\Delta X_{1i})(1-\mu\cdot sgn\Delta X_{1i})P_1+E_1[D+(1+\tau_{EX,2}\cdot sgn\Delta X_{2i})P_2+1]\beta_2\]

\[-2A_i\text{Cov}[Z_{2i},D]\]

\[=\frac{2A_i\text{Var}[D]}{2A\text{Var}[D]}\]

Thus

\[X^*_{OTC,1i} + \alpha_1 = X^*_{EX,1i}\]

where homologously to the relationship between asset demands in period 2,

\[\alpha_1 = \frac{\beta_1}{A\text{Var}[D]}; \beta_1 = [(1+\tau_{OTC,1}\cdot sgn\Delta X_{1i})(1-\mu\cdot sgn\Delta X_{1i})-(1+\tau_{EX,1}\cdot sgn\Delta X_{1i})]P_1\]

\[= [(\tau_{OTC,1}-\mu-\tau_{EX,1})\cdot sgn\Delta X_{1i}-\mu\tau_{OTC,1}P_1].\]

A net first period buyer will choose to trade OTC if

\[X^*_{EX,1i} \geq \frac{E_1\left\{2\tau_{EX,1}\cdot sgn\Delta X_{1i}P_1+2(\tau_{OTC,1}+\mu(1+\tau_{OTC,1})-\tau_{EX,1})\cdot sgn\Delta X_{1i}P_1\right\} \alpha_1-4\gamma}{4\mu(1+\tau_{OTC,1})\cdot sgn\Delta X_{1i}P_1} + X_0 = Z_{1i}\]

**Proposition 7.** Given \(\tau_1=0, \tau_2>0\) in all markets, there is a smaller lock-in effect for OTC trading, which can be further dominated by a platform-shifting avoidance strategy for a sufficiently high density of traders close to the OTC participation indifference threshold.

There is naturally no inaction region per se observed in OTC, since previously untaxed OTC investors either trade less in period 2 relative to period 1 (retiming and permanent lock-in) but remain active OTC (if inframarginal), or trade less and shift platform to on-exchange (if at the margin of platform selection). For a sufficiently high share of OTC traders close to the indifference threshold, the absence of as sizable a lock-in effect for the remaining OTC traders can be explained in this model by a lower elasticity of period 2 transaction sizes with respect to the tax wedge OTC than on-exchange. Intuitively, the increase in marginal cost induced by the tax is smaller in proportion to the marginal return on asset sales (due to the OTC markup) in the former. This result is consistent with the empirical finding in chapter 1 of a permanent lock-in effect OTC close to zero. On the other hand, proposition 7 has implications for rationalizing a higher lock-in elasticity displayed by high-frequency traders relative to non-algorithmic on-exchange traders shown in chapter 1.

This can be shown formally by comparing the relative magnitude of the responses of \(X^*_{OTC,2i}\) and \(X^*_{EX,2i}\) with respect to marginal changes in own-platform
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

For simplicity, assume \( \int_{\mathcal{T}} sgn \Delta X_{2i} dF (i) = +29 \), so there is net buying pressure on both markets overall; non-trivially, this implies \( \frac{dP_2}{d\tau_{OTC}} \approx \frac{dP_2}{d\tau_{EX}} < 0 \). I restrict the analysis here to the case of a second period buyer (\( \Delta X_{2i}^* > 0 \)), but the reciprocal also holds for sellers in the case of a market with net selling pressure\(^{30} \). Further, notice that since \( \frac{dX_{OTC}}{d\tau_{OTC}}|_{\tau_{EX}=0} sgn \Delta X_{2i} = + < 0 \) and \( \frac{dX_{EX}}{d\tau_{EX}}|_{\tau_{OTC}=0} sgn \Delta X_{2i} = + < 0 \), I compare the absolute values of these derivatives for equivalently sized marginal tax changes (i.e., \( \tau_{OTC} = \tau_{EX} = \bar{\tau} \) in what follows):

\[
\left| \frac{dX_{OTC}}{d\tau_{OTC}}|_{\tau_{EX}=0, sgn \Delta X_{2i}=+} - \frac{dX_{EX}}{d\tau_{EX}}|_{\tau_{OTC}=0, sgn \Delta X_{2i}=+} \right| = \left| \frac{-2(1-\mu)P_2}{AVar[D]} - \frac{2}{AVar[D]} \cdot \frac{2(1+\tau_{OTC})(1-\mu)}{d\tau_{OTC}} \frac{dP_2}{d\tau_{OTC}} \right| - \left| \frac{-2P_2}{AVar[D]} - \frac{2}{AVar[D]} \cdot \frac{2(1+\tau_{EX})}{d\tau_{EX}} \frac{dP_2}{d\tau_{EX}} \right| \leq \left| \frac{2\mu P_2}{AVar[D]} + \frac{2(1+\bar{\tau})\mu}{AVar[D]} \frac{dP_2}{d\tau_{OTC}} \right| \tag{2.14}
\]

Equation (2.14) corresponds to the absolute difference between the numerators of the own-price turnover elasticity, holding \( X_{1i} \) constant. Intuitively, it tells us that for a unit change in the marginal tax rate, optimal OTC holdings of the risk asset decline by more in absolute value than those on-exchange; for a buyer, this implies her optimal transaction size declines more OTC. However, notice the denominator of the respective own-price turnover elasticity (the pre-tax optimum) is also different in each case. In particular, the denominator increases by:

\[
X_{OTC} - X_{EX} = + \frac{2\mu P_2}{AVar[D]}|_{\bar{\tau}=0} \tag{2.15}
\]

Comparing (2.14) and (2.15) yields

\[
\left| \frac{2\mu P_2}{AVar[D]} + \frac{2(1+\tau_{OTC})\mu}{AVar[D]} \cdot \frac{dP_2}{d\tau_{OTC}} \right| < \left| \frac{2\mu P_2}{AVar[D]} \right|
\]

Since the absolute value of the decline on numerator is smaller than increase in denominator, for a given value of \( X_{1i} \) the own-price turnover elasticity OTC must be relatively smaller. Moreover, since we assumed net buying pressure in both markets, the aggregate average elasticity (integrating over \( i \in \mathcal{T} \)) must also be relatively smaller.

\(^{28} \)Notice this measure is closely related to the turnover elasticity for a given market defined as \( \frac{dX_{M,2i}}{d(\tau_{M})} \), \( M=\{OTC,EX\} \), and is in fact equivalent when holding \( X_{1i} \) constant.

\(^{29} \)In addition, I set \( dsgn \Delta X_{2i} = 0 \).

\(^{30} \)Such that \( \frac{dP_2}{d\tau_{EX}} > 0 \).
Equilibrium prices

Lemma 5. In period 2, taking \( P_1 \) and \( X_{1i} \) as given, and using the allocations derived above, \( P_2 \) solves the market clearing condition on-exchange\(^{31}\):

\[
\int_{i \in T_{EX,2}} \frac{E_2 (1 + D) - ACov_i (Z_{3i}, D) - AVar (D) X_{1i}}{2 (1 + \tau_{EX,2 sgn \Delta X_{2i}})} dF (i) = P_2
\]

where \( T_{EX,t} \) represents the set of traders on-exchange in period \( t \).

As previously mentioned, OTC takes \( P_2 \) as given from the regulated exchange. Market-clearing OTC (equivalent to \( P_{EX,2} = P_{OTC,2} = P_2 \)) is guaranteed by arbitrageurs unconstrained by \( \gamma \).\(^{32}\)

In period 1, after substituting for \( P_2 \), similar market clearing conditions give us

\[
\int_{i \in T_{EX,1}} \frac{E_1 \left[ 2D + \left\{ \int_{i \in T_{EX,2}} \frac{E_2 (1 + D) - ACov_i (Z_{3i}, D) - AVar (D) X_{1i} dF (i)}{4(1 + \tau_{EX,1 sgn \Delta X_{1i}})} \right\} \right]}{4(1 + \tau_{EX,1 sgn \Delta X_{1i}})} dF (i) = P_1
\]

(2.16)

Optimal Ramsey taxes with two markets

In what follows, I abstract from Pigouvian concerns and focus only on the optimal tax mix given a revenue-raising objective. A direct application of the benchmark Diamond and Mirrlees (1971b) optimal tax formulas based on demand elasticities is not sufficient in a portfolio selection model when linear transaction taxes are the only tax instruments available to the government. Notably, the results of such standard models require either i) a lack of pure profits\(^{33}\) or ii) 100% taxation of such profits. In the current setup, the supply of the risky asset \( Q \) is exogenously fixed, so price-taking consumers cannot guarantee the absence of rents in equilibrium - there are untaxed capital gains, dividend payments and unobservable heterogeneous

\(^{31}\)For the description of the restrictions used in deriving equilibrium prices in a two-market setting please see Appendix section 2.

\(^{32}\)Notice that as \( \gamma \to 0 \), in order to guarantee some trading in both markets, if \( sgn \Delta X_{2i} \succ (\prec) 0 \) we must have \( P_{EX} \to [1 - \mu] [(1 + \mu) P_{OTC}] \), so that \( \forall \gamma, P_{EX} \in [(1 - \mu) P_{OTC}, (1 + \mu)] \) irrespective of introducing a set of inter-market arbitrageurs.

\(^{33}\)Ensured in Diamond and Mirrlees (1971b) by having price-taking households and a constant-returns-to-scale production function.
endowment shocks in every period; furthermore, these are untaxed. For example, one can imagine an individual whose hedging needs in every period are such that it is optimal for her to not enter into any transaction until the terminal period \( t = 3 \), such that her tax liability from an FTT is always zero. Liquidating its risky assets for consumption at a normalized \( P^3 = 1 \), this individual will however incur capital gains/losses from period-to-period changes in prices of asset holdings, in addition to dividend returns on the same assets, the accumulation of which is untaxed. Thus, without further restrictions on the social planner’s optimization problem, a critical assumption of Diamond and Mirrlees (1971b) breaks down in the present setting, requiring modified optimal tax formulas.

Analogously to the single market problem, I set \( \tau_{EX,1,1} = \tau_{OTC,1,1} = 0 \). The optimal linear tax rates then solve the following problem

\[
\max_{\tau_{EX,2,2}, \tau_{OTC,2,2}} \int \lambda_i V_i dF(i)
\]

s.t.

\[
\tau_{EX,2} P_2 \int_{i \in EX} |\Delta X_{EX,2i}| dF(i) + \tau_{OTC,2} P_2 \int_{i \in OTC} |\Delta X_{OTC,2i}| dF(i)
\]

\[
-\tau_{OTC} \mu P_2 \int_{i \in OTC} \Delta X_{OTC,2i} dF(i) \geq R
\]

where \( V_i \) is defined as in the previous section, \( R \) is some exogenous non-transfer government spending target and

\[
\frac{dV_i}{d\tau} = Ae^{-A \hat{V}_i} \frac{d\hat{V}_i}{d\tau} = E\left[U_i'(W_{3i})\right] \frac{d\hat{V}_i}{d\tau}
\]

The corresponding Lagrangian is

\[
\mathcal{L} = \int_{i \in \mathcal{T}} \lambda_i V_i dF(i) - \delta \left\{ \tau_{EX,2} + \mathbb{1}_2 (\tau_{OTC,2} - \tau_{EX,2}) \right\} \cdot P_2 \int_{i \in \mathcal{T}} \text{sgn}(\Delta X_{EX,2i}) \{(X_{EX,2i} - \mathbb{1}_2 \alpha_2)\} dF(i)
\]

\[
+ \delta \left\{ \tau_{EX,2} + \mathbb{1}_2 (\tau_{OTC,2} - \tau_{EX,2}) \right\} \cdot P_2 \int_{i \in \mathcal{T}} \text{sgn}(\Delta X_{EX,2i}) \{(X_{EX,2i} - \mathbb{1}_1 \alpha_1)\} dF(i) + R
\]

With no lump-sum tax rebates, and \( E(D) = E_{ti}(D) \), \( \forall t, i \), the certainty equivalent \( \hat{V}_i \) (fully derived in Appendix section 2) is a function of both risky asset holdings in each period and OTC participation \( 1_1 \) and \( 1_2 \). Note that \( 1 \) is a non-differentiable Heaviside step function; in order to obtain an approximate closed form analytic solution to the social planner’s problem, in what follows I impose a smooth approximation

\[\text{Note the presence of untaxed rents would still hold in an infinite horizon extension of the current model, as long as some fraction of capital gains/dividend payments were not reinvested in portfolio changes, but rather consumed in each period.} \]
of this function with a logit function with mean 0. In particular, $1_t \approx \frac{1}{1+e^{-x_t}} = \theta_t$, where $k$ is a distributional parameter affecting the slope of the logit CDF, and $x_t = \text{sgn}(\Delta X_{ti}(X^*_t + Z_{ti})$. The marginal change in investor welfare caused by introducing $\tau_{EX,2} = \tau_{EX} \left( \frac{d\hat{\psi}}{d\tau_{EX}} \right)$ and $\tau_{OTC} = \tau_{OTC} \left( \frac{d\hat{\psi}}{d\tau_{OTC}} \right)$, as well as the FOCs with respect to $\tau_{EX}$ and $\tau_{OTC}$ are likewise derived in Appendix section 2.

Denote $\lambda_{i} E[U_{i}'(W_{3i})] \equiv g_{i}$. Then,

$$
\tau_{EX}^{*} = \frac{\eta_{EX} - \tau_{OTC} \left\{ \psi_{EX} \int_{i \in B} \theta_{i} dF(i) + \kappa_{OTC} \right\}}{\psi_{EX} \int_{i \in B} (1 - \theta_{i}) dF(i)}
$$

(2.17)

where

$$
\eta_{EX} \equiv 2P_{2} \int_{i \in B} [\Delta X_{B,2i}] (1 - \theta_{i}) dF(i) \cdot \left[ 2 \int_{i \in B} g_{i} dF(i) + \delta \right] \quad \text{Social utility of taxable income and distortion to idiosyncratic risk exposure}
$$

$$
\psi_{EX} \equiv -2 \frac{dP_{2}}{d\tau_{EX}} \int_{i \in B} \frac{d\Delta X_{B,2i}}{d\tau_{EX}} dF(i) \cdot \left[ 2 \int_{i \in B} g_{i} dF(i) + \delta \right] \quad \text{Terms-of-trade}
$$

$$
+2\delta P_{2} \int_{i \in B} \frac{d\theta_{i}}{d\tau_{EX}} \Delta X_{B,2i} dF(i) \cdot \left[ 2 \int_{i \in B} g_{i} dF(i) + \delta \right] \cdot \frac{1}{\int_{i \in B} (1 - \theta_{i}) dF(i)} \quad \text{Fundamental distortion}
$$

and $\kappa_{OTC} \equiv -2P_{2} \int_{i \in B} \frac{d\theta_{i}}{d\tau_{EX}} [\Delta X_{B,2i}] dF(i) \cdot \left[ \frac{1}{\int_{i \in B} (1 - \theta_{i}) dF(i)} \cdot \left[ 2 \int_{i \in B} g_{i} dF(i) + \delta \right] 
$$

$$
+2\mu \int_{i \in T} G_{i} \left( \frac{d\theta_{i}}{d\tau_{EX}} + \frac{d\theta_{2}}{d\tau_{EX}} \right) \cdot [\Delta X_{T,2i}] dF(i).
$$

Here $\int_{i \in T} \Delta X_{T,2i} dF(i) \equiv \int_{i \in T} (X_{EX,2i} - \theta_{2} \alpha_{2} - (X_{EX,1i} - \theta_{1} \alpha_{1}) dF(i)$ represents the overall size of trades in both markets in the second period, $\frac{d\Delta X_{B,2i}}{d\tau_{EX}} = \frac{dX_{EX,2i}}{d\tau_{EX}} - \frac{d\theta_{2} \alpha_{2}}{d\tau_{EX}} - \frac{d\theta_{1} \alpha_{1}}{d\tau_{EX}}$
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

\[
\left( \frac{dX_{E_X}}{dX_{E_X}} - \frac{d\theta_1}{d\tau_{E_X}} \right), \quad \text{and } B \text{ represents the set of buyers in all markets.}^{35}
\]

Notice the first term in \( \eta_{E_X} \) is equal to 1) the distortion to self-insurance as discussed in section 2.2 plus 2) the nominal value of the relevant tax base multiplied by the sum of the social marginal utility of wealth and the shadow cost of the government revenue constraint, which can therefore be thought of as the overall social utility of taxable income. Moreover, beyond the pure rents resulting from the OTC market design constructed in this paper, the FOCs underlying equation (2.17) differ in an important way from what would be implied by a direct application of Diamond and Mirrlees (1971b)'s heterogeneous agent extension of Ramsey (1927). Specifically, we see now the social marginal utility of consumption \( 2 \int_{i \in B} g_i dF(i) \) multiplying the terms-of-trade and market structure distortions, which inhibit an expression of the optimal tax rates exclusively in terms of elasticities of demand for the taxed transactions.

Similarly with respect to \( \tau_{OTC} \), let

\[
\psi_{OTC} = -2 \frac{dP_2}{d\tau_{OTC}} \int_{i \in B} \left[ \Delta X_{B,2i} \right] dF(i) \cdot 2 \int_{i \in B} g_i dF(i) + \delta \\
-2 \delta \cdot P_2 \int_{i \in B} \left[ \frac{d\Delta X_{B,2i}}{d\tau_{OTC}} \right] dF(i) \\
-2P_2 \int_{i \in B} \left[ \frac{d\theta_2}{d\tau_{OTC}} \right] \left[ \Delta X_{T,2i} \right] dF(i) \cdot 2 \int_{i \in B} g_i dF(i) + \delta \cdot \frac{1}{\int_{i \in B} \theta_2 dF(i)} \\
+4 \mu P_2 \int_{i \in B} g_i \left[ \Delta X_{T,2i} \right] dF(i) \\
+4 \mu \frac{dP_2}{d\tau_{OTC}} \int_{i \in B} g_i \left[ \Delta X_{B,2i} \right] dF(i)
\]

where \( \frac{d\Delta X_{B,2i}}{d\tau_{OTC}} = \frac{dX_{E_X,2i}}{d\tau_{OTC}} - \frac{d\theta_2}{d\tau_{OTC}} \left( \frac{dX_{E_X,1i}}{d\tau_{OTC}} - \frac{d\theta_1}{d\tau_{OTC}} \right), \quad \text{and} \)

\(^{35}\text{This simplification requires that the individual social welfare function weights } g_i \text{ be symmetric between buyers and sellers.}\)
\(\eta_{\text{OTC}} = 2P_2 \int_{i \in B} \left[ \Delta X_{B,2i} \theta_2 dF(i) \cdot \left[ 2 \int_{i \in B} g_i dF(i) + \delta \right] \right] \) Social utility of taxable income and distortion to idiosyncratic risk exposure

\[-4\mu P_2 \int_{i \in B} g_i \frac{d\theta_2}{d\tau_{\text{OTC}}} [\Delta X_{B,2i}] dF(i) + \frac{dP_2}{d\tau_{\text{OTC}}} \int_{i \in B} (1 - \mu \theta_2) g_i [\Delta X_{B,2i}] dF(i) + \frac{dP_2}{d\tau_{\text{OTC}}} \int_{i \in B} (1 - \mu \theta_1) g_i [\Delta X_{B,1i}] dF(i) + 2 \gamma \int_{i \in T} g_i \frac{d\theta_1}{d\tau_{\text{OTC}}} dF(i) + 4 \gamma \int_{i \in T} g_i \frac{d\theta_1}{d\tau_{\text{OTC}}} dF(i) \]

OTC rents distortion

Note the last 5 summands in this expression reflect the change in net rents obtained by OTC traders as a result of the introduction of \(\tau_{\text{OTC}}\). So

\[\tau^*_\text{OTC} = \frac{\eta_{\text{OTC}} \cdot \psi_{\text{OTC}} \int_{i \in B} (1 - \theta_2) dF(i) + \kappa_{\text{EX}}}{\psi_{\text{OTC}} \int_{i \in B} \theta_2 dF(i)} - \frac{\eta_{\text{EX}} \cdot \psi_{\text{OTC}} \int_{i \in B} (1 - \theta_2) dF(i) + \kappa_{\text{EX}}}{\lambda} \]

(2.18)

where \(\lambda\) is defined as

\[\lambda = \psi_{\text{EX}} \cdot \psi_{\text{OTC}} \int \int_{i \in B} \theta_2 (1 - \theta_2) dF(i) dF(j) (1 - \mathcal{K})\]

and \(\mathcal{K}\) as

\[\mathcal{K} = \left[ \frac{\psi_{\text{EX}} \int_{i \in B} \theta_2 dF(i) + \kappa_{\text{OTC}}}{\psi_{\text{EX}} \cdot \psi_{\text{OTC}} \int_{i \in B} \theta_2 (1 - \theta_2) dF(i) dF(j)} \cdot \left( \psi_{\text{OTC}} \int_{i \in B} (1 - \theta_2) dF(i) + \kappa_{\text{EX}} \right) \right] \]

\(^{36}\)Note further that \(\frac{\eta_{\text{OTC}}}{\eta_{\text{EX}}} < 0\), so \(\tau^*_\text{OTC}\) is decreasing in the net rents lost OTC. This result is an artifact of the particular model specification here, where the welfare of arbitrageurs is not part of the social planner’s maximand.

\(^{37}\int_{i \in B} \theta_2 dF(i) \int_{i \in B} (1 - \theta_2) dF(i) = \int \int_{i \in B} \theta_2 (1 - \theta_2) dF(i) dF(j)\) follows from Fubini’s theorem.
Plugging this back into (2.17) gives us

\[
\tau^{\star}_{EX} = \frac{\eta_{EX} \cdot \psi_{OTC} \int_{i \in T} \theta_2 dF(i) - \eta_{OTC} \cdot \psi_{EX} \int_{i \in T} \theta_2 dF(i) + \kappa_{OTC}}{\lambda}
\]

Having independent expressions for each ad valorem tax rate for the two types of transactions, we can obtain the ratio between them, which should hold at the optimum, irrespective of the level of revenue \( R \) sought. Under no further restrictions,

\[
\frac{\tau^{\star}_{EX}}{\tau^{\star}_{OTC}} = \frac{[\eta_{EX} \cdot \psi_{OTC} - \eta_{OTC} \cdot \psi_{EX}] \int_{i \in B} \theta_2 dF(i) - \eta_{OTC} \cdot \kappa_{OTC}}{[\eta_{OTC} \cdot \psi_{EX} - \eta_{EX} \cdot \psi_{OTC}] \int_{i \in B} (1 - \theta_2) dF(i) - \eta_{EX} \cdot \kappa_{EX}}
\]

(2.19)

In order to simplify the economic interpretation of this ratio, focusing as much as possible on terms generalizable beyond the setup of the current model, in the remainder of the section I drop any terms pertaining to OTC-specific externalities/rents\(^{38}\).

In the absence of such rents, (2.19) can be rearranged to

Notice this ratio can be rearranged as where \( \eta_{EX} \) and \( \eta_{OTC} \) now include only the first summand in their original definition.

Here \( \eta_{OTC} \cdot \psi_{EX} \int_{i \in B} \theta_2 dF(i) + \kappa_{OTC} \) is the partial derivative of the OTC tax base with respect to \( \tau_{EX} \), and \( \eta_{EX} \cdot \psi_{OTC} \int_{i \in B} (1 - \theta_2) dF(i) + \kappa_{EX} \) the partial derivative of the on-exchange tax base with respect to \( \tau_{OTC} \) (the “cross-price” effects).

**Proposition 8.** Given no OTC-specific externalities/rents, the equi-proportional version of the Ramsey rule for the optimal transaction tax system given a segmented market and heterogeneous agents becomes

\[
\tau^{\star}_{EX} \cdot \psi_{OTC} \int_{i \in B} (1 - \theta_2) dF(i) \psi_{EX} + \tau^{\star}_{OTC} \cdot \eta_{OTC} \cdot \psi_{EX} \int_{i \in B} \theta_2 dF(i) + \kappa_{OTC}
\]

\[= \tau^{\star}_{EX} \cdot \psi_{OTC} \int_{i \in B} (1 - \theta_2) dF(i) \psi_{EX} + \tau^{\star}_{OTC} \cdot \eta_{EX} \int_{i \in B} \theta_2 dF(i) \psi_{OTC}
\]

Equation (2.20) is obtained directly by rearranging (2.19). It implies in particular that the overall change in the quantity demanded of OTC assets induced by both taxes be of equal proportion to that induced in the quantity demanded of on-exchange

---

\(^{38}\)In particular terms including either \( \mu \) or \( \gamma \). Hence, rents arising from capital gains, dividend and exogenous endowment accumulation remain in the analysis below.
assets. Unlike most standard commodity taxation problems however, (2.20) cannot be simplified to the inverse elasticity version of the Ramsey rule, as (i) the cross-price partial derivatives of the compensated demand functions are not symmetric due to the latter’s discontinuity, and (ii) we would have to ignore “cross-price” effects to obtain the standard result; in the present case, with assets traded in the two platforms being substitutes, these effects are non-zero, making their omission non-trivial.

Furthermore, note in order to obtain quantifiable equivalents of version (2.20) of the re-arranged $\frac{\tau_{EX}}{\tau_{OTC}}$ ratio we would need to know the increase in social welfare associated with a unit increase in consumption of each investor $(g_i)$. In practice, doing so is not only difficult to implement (since we do not observe individual endowment shocks or marginal utilities of consumption in the data), but it may also arguably be negligible from a policy perspective if either the social planner does not place a high value $\lambda_i$ on the welfare of financial market participants (possibly consistent with a highly redistributive overall social welfare criterion\(^{39}\), or one where distributional considerations among investors alone are not a policy objective), or these agents are at sufficiently high income levels that we can reasonably infer their marginal utility of an additional unit of consumption to be close to zero. Under such arguments, we can illustratively set $\int_{i\in\mathcal{I}} g_i dF(i) \approx 0$ (and redefine $\eta_{EX}$ and $\eta_{OTC}$ accordingly).

Taking the limit as $\theta_2 \to 1$,\(^{39}\)

\(^{39}\)In other words, a social welfare criterion including non-financial market participants.
Re-expressing (2.21) in terms of elasticities, we have

\[
\lim_{\theta_2 \to 1} \frac{\tau_{EX}^*}{\tau_{OCX}^*} = \frac{\int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ -\frac{d\theta_2}{d\tau_{OCX}} \int_{\epsilon B} \Delta X_{B,2} \underline{l}_2 dF(i) \right\}}{\int_{\epsilon B} [\Delta X_{B,2}] \underline{l}_2 dF(i) \cdot \left\{ -\frac{d\theta_2}{d\tau_{OCX}} \int_{\epsilon B} \Delta X_{B,2} \underline{l}_2 dF(i) \right\}}
\]

\[
+ \int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ -P_2 \int_{\epsilon B} \left[ \frac{d\Delta X_{B,2}}{d\tau_{OCX}} \right] \underline{l}_2 dF(i) \right\}
\]

\[
+ \int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ -P_2 \int_{\epsilon B} \left[ \frac{d\Delta X_{B,2}}{d\tau_{EX}} \right] \underline{l}_2 dF(i) \right\}
\]

\[
+ \int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ -P_2 \int_{\epsilon B} \left[ \frac{d\theta_2}{d\tau_{OCX}} \right] \Delta X_{B,2} dF(i) \right\}
\]

\[
+ \int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ P_2 \int_{\epsilon B} \left[ \frac{d\theta_2}{d\tau_{OCX}} \right] \Delta X_{B,2} dF(i) \right\}
\]

\[
+ \int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ P_2 \int_{\epsilon B} \left[ \frac{d\theta_2}{d\tau_{EX}} \right] \Delta X_{B,2} dF(i) \right\}
\]

\[
\text{(2.21)}
\]

Re-expressing (2.21) in terms of elasticities, we have

\[
\frac{\tau_{EX}^*}{\tau_{OCX}^*} = \frac{\int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \int_{\epsilon B} \underline{l}_2 dF(i) \cdot \left\{ \frac{\epsilon_{OCX} + \epsilon_{OCX} \tau_{OCX}}{1-\epsilon_{OCX}} \int_{\epsilon B} \Delta X_{B,2} dF(i) \right\}}{\int_{\epsilon B} [\Delta X_{B,2}] \underline{l}_2 dF(i) \cdot \left\{ \frac{d\theta_2}{d\tau_{OCX}} \int_{\epsilon B} \Delta X_{B,2} \underline{l}_2 dF(i) \right\}}
\]

\[
+ \int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ \frac{\epsilon_{OCX} + \epsilon_{OCX} \tau_{OCX}}{1-\epsilon_{OCX}} \int_{\epsilon B} \Delta X_{B,2} \underline{l}_2 dF(i) \right\}
\]

\[
+ \int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ \frac{\epsilon_{OCX} + \epsilon_{OCX} \tau_{OCX}}{1-\epsilon_{OCX}} \int_{\epsilon B} \Delta X_{B,2} \underline{l}_2 dF(i) \right\}
\]

\[
+ \int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ \frac{d\theta_2}{d\tau_{OCX}} \int_{\epsilon B} \Delta X_{B,2} \underline{l}_2 dF(i) \right\}
\]

\[
+ \int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ \frac{d\theta_2}{d\tau_{OCX}} \int_{\epsilon B} \Delta X_{B,2} \underline{l}_2 dF(i) \right\}
\]

\[
+ \int_{\epsilon B} [\Delta X_{B,2}](1-\underline{l}_2) dF(i) \cdot \left\{ \frac{d\theta_2}{d\tau_{OCX}} \int_{\epsilon B} \Delta X_{B,2} \underline{l}_2 dF(i) \right\}
\]

\[
\text{where } \epsilon_{\text{platform}} = \frac{\frac{d\theta_2}{d\tau_{OCX}} - \frac{d\theta_2}{d\tau_{EX}}}{\frac{d\theta_2}{d\tau_{OCX}} - \frac{d\theta_2}{d\tau_{EX}}}, \text{ with } \epsilon_{\text{EX}} = \epsilon_{\text{platform}} |_{\tau_{OCX} = 1} = \frac{-d\theta_2/d\tau_{OCX}}{\theta_2/(1-\tau_{OCX}) - \tau_{OCX}} \text{ and } \epsilon_{\text{platform}} = \epsilon_{\text{platform}} |_{\tau_{OCX} = 1} = \frac{-d\theta_2/d\tau_{OCX}}{\theta_2/(1-\tau_{OCX}) - \tau_{OCX}}.
\]
Proposition 9. Under a policy objective with no equity component and no rents, if \( \int_{i \in B} \frac{1}{2} dF(i) = \frac{1}{2} \), the ratio between optimal transaction taxes \( \frac{\tau_{EX}^*}{\tau_{OTC}^*} \) is inversely proportional to the own-price elasticities of each segment; if \( \int_{i \in B} \frac{1}{2} dF(i) \neq \frac{1}{2} \), then market-specific own-price and turnover elasticities, as well as the platform-shifting elasticity and relative market shares are sufficient statistics for the optimal tax ratio. This ratio is given by:

\[
\frac{\tau_{EX}^*}{\tau_{OTC}^*} = \frac{1 + \int_{i \in B} [\Delta X_{B2i}] (1 - \frac{1}{2}) dF(i) \cdot \left\{ \int_{i \in B} \Delta X_{B2i} \frac{1}{2} dF(i) \cdot (\epsilon_{pX}^{\text{OTC}} + \epsilon_{\text{turnover}}^{\text{OTC}}) \right\}}{1 + \int_{i \in B} [\Delta X_{B2i}] (1 - \frac{1}{2}) dF(i) \cdot \left\{ \int_{i \in B} \Delta X_{B2i} (1 - \frac{1}{2}) dF(i) \cdot (\epsilon_{pX}^{\text{EX}} + \epsilon_{\text{turnover}}^{\text{EX}}) \right\}} + \int_{i \in B} [\Delta X_{B2i}] (1 - \frac{1}{2}) dF(i) \cdot \left\{ \epsilon_{\text{platform}} \int_{i \in B} \Delta X_{B2i} \frac{1}{2} dF(i) \right\} \bigg] \frac{\epsilon_{\text{platform}} \int_{i \in B} \Delta X_{B2i} \frac{1}{2} dF(i)}{\int_{i \in B} [\Delta X_{B2i}] (1 - \frac{1}{2}) dF(i)}
\]

(2.22)

Setting \( \int_{i \in T} g_i dF(i) = 0 \) then leads to optimal taxation of a form akin to that described in Diamond and Mirrlees (1971b) for the case of constant social marginal utility of income - inversely proportional to the respective elasticities of demand. However, since the elasticity of platform shifting is not constant across the distribution of investors, average elasticities alone are not sufficient to determine the ratio of optimal taxes. Hence the necessary weighting by the relative market shares \( \frac{\int_{i \in B} [\Delta X_{B2i}] (1 - \frac{1}{2}) dF(i)}{\int_{i \in B} [\Delta X_{B2i}] (1 - \frac{1}{2}) dF(i)} \). For a given \( \tau_{OTC} \), \( \tau_{EX}^* \) is thus increasing in the elasticity of overall market volume and market structure with respect to \( \tau_{OTC} \) (\( \epsilon_{pX}^{\text{OTC}} \), \( \epsilon_{\text{turnover}}^{\text{OTC}} \)) and declining in its own elasticities (\( \epsilon_{pX}^{\text{EX}} \), \( \epsilon_{\text{turnover}}^{\text{EX}} \)). In addition, \( \tau_{EX}^* \) is increasing in the relative market share of on-exchange trades. Therefore, given the current framework, the optimal tax mix attenuates the existing market structure. This would not necessarily be the case if negative externalities accruing from OTC trading (such as price opacity, lack of timely transaction reporting, etc) were present; in such cases it could be optimal to accentuate the existing market structure even if the pre-tax share of the externality-generating sector were the smallest. Furthermore, the tendency for the tax mix to attenuate the existing market structure is exacerbated by

\[
\frac{-d\theta_2/d\tau_{EX}^*}{\theta_2(1 - \tau_{EX}^*)} = \frac{-d\theta_2/d\tau_{EX}^*}{\theta_2(1 - \tau_{EX}^*)} \quad \text{(by the condition imposed in the previous paragraph)}, \quad \text{so} \quad \epsilon_{pX}^{\text{OTC}} = \frac{-\epsilon_{\text{platform}}}{\theta_2(1 - \tau_{OTC}^*)}, \quad \text{given} \quad \tau_{OTC} \approx \tau_{EX} \text{ pre-tax reform (always true when starting from an untaxed environment)}, \quad \text{this simplifies to} \quad \epsilon_{pX}^{\text{OTC}} \approx -\epsilon_{\text{platform}}, \quad \text{and the above identity follows.}
the interaction of the elasticity of the OTC market share with respect to the tax wedge \(\epsilon_{\text{platform}}\) with the relative on-exchange market share\(^{41}\).

Notwithstanding, the simplified ratio in (2.22) is still informative even when refraining from strong restrictions on the social marginal utility of income. In particular, it allows us to compare the true \(\frac{\tau_{\text{EX}}}{\tau_{\text{OTC}}}\) with bounds whose parameters are entirely empirically measurable (and that do not depend on \(\int_{i\in B} dF(i)\)), as shown by equation (2.24) below.

\[
\frac{\tau_{\text{EX}}}{\tau_{\text{OTC}}}(1-\tau_{\text{OTC}}) > \langle \int_{i\in B} [\Delta X_{B,2i}]_2 (1-\mathbb{1}_2) dF(i) \rangle \cdot \left\{ \int_{i\in B} \Delta X_{B,2i} \mathbb{1}_2 dF(i) \cdot \left[ \epsilon_{\text{OTC}} + \epsilon_{\text{turnover}} \right] \right\} \]

\[
+ \int_{i\in B} [\Delta X_{B,2i}]_2 dF(i) \cdot \left\{ \epsilon_{\text{platform}} \int_{i\in B} \Delta X_{B,2i} \mathbb{1}_2 dF(i) \right\}
\]

\[
\text{iff} \quad \left\{ \begin{array}{ll}
\int_{i\in B} [\Delta X_{B,2i}]_2 > (\langle \rangle \frac{1}{2}) \text{ if } \frac{dP_2}{d\tau_{\text{EX}}} \int_{i\in B} \Delta X_{B,2i} dF(i) > 0 \\
\int_{i\in B} [\Delta X_{B,2i}]_2 < (\langle \rangle \frac{1}{2}) \text{ if } \frac{dP_2}{d\tau_{\text{EX}}} \int_{i\in B} \Delta X_{B,2i} dF(i) < 0
\end{array} \right. \quad (2.23)
\]

where in order to establish the inequality I use \(\int_{i\in T} g_i dF(i) > 0, dP_2/d\tau_{\text{EX}} \approx dP_2/d\tau_{\text{OTC}}, \) and \(d\theta_2/d\tau_{\text{OTC}} \approx -d\theta_2/d\tau_{\text{EX}}.\) Notice further that empirically we find that \(\frac{dP_2}{d\tau_{\text{EX}}} \int_{i\in B} \Delta X_{B,2i} dF(i) < 0\) (see Umlauf (1993); Bond et al. (2004) and chapter 1), so the second condition should hold.

**Proposition 10.** Given the conditions above, if \(\int_{i\in B} [\Delta X_{B,2i}]_2 > \frac{1}{2}\) (where more than 50% of trades are executed OTC), the right-hand side of (2.24) is an upper bound for \(\tau_{\text{EX}}/\tau_{\text{OTC}}\) (and a lower bound otherwise). If \(\int_{i\in B} [\Delta X_{B,2i}]_2 = \frac{1}{2}\), \(\tau_{\text{EX}}/\tau_{\text{OTC}}\) is akin to the standard inverse elasticity rule for commodity taxation, dependent only on corresponding elasticities of demand.

If \(\int_{i\in B} [\Delta X_{B,2i}]_2 = \frac{1}{2}\), transactions in one platform or another are closer substitutes at the margin for a larger share of agents (relative to the inframarginal density); this implies the share of individuals with the highest platform shifting elasticity relative to all individuals in each market (those at the fence between trading in one market or another) is the same for both markets; therefore, the most efficient tax system should set \(\tau_{\text{EX}}^*, \tau_{\text{OTC}}^*\) such that market structure converges to \(\frac{1}{2}\). Furthermore, at \(\int_{i\in B} [\Delta X_{B,2i}]_2 = \frac{1}{2}\), market structure is no longer a determinant of tax

\(^{41}\)Higher values of \(\epsilon_{\text{platform}}\) imply a higher (lower) relative \(\tau_{\text{EX}}^*\) if on-exchange trades represent the dominant (smaller) market.
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

ratio efficiency, and we are left with a standard inverse elasticity rule. The same analysis of the economic intuition underlying equation (2.22) carries over to (2.24).

Figures 2.5 and 2.6 show changes in these bounds for different simulated ranges of $\tau^*_{OTC}$ levels and initial values of the OTC market share $\left( \beta \int_{B} dF(i) \right)$, given empirical estimates for $\epsilon_{px}, \epsilon_{EX}, \epsilon_{turnover}, \epsilon_{OTC}$, and $\epsilon_{Platform}$ from Chapter 1. The choice of set for evaluating $\beta \int_{B} dF(i)$ aims to replicate a similar scenario to the pre-existing market structure before the introduction of an FTT on equity markets in Italy in 2013 ($\beta \int_{B} dF(i) = \frac{1}{3}$), and France in 2012 ($\beta \int_{B} dF(i) = \frac{2}{3}$).

Finally, the FOC with respect to $\delta$, the multiplier of the government revenue constraint, yields:

$$2P \frac{1}{\Lambda} \cdot \beta \int_{B} \left\{ \left( 1 - \theta \right) \tau_{EX} + \theta \tau_{OTC} \right\} \cdot \Delta X_{B,2i} dF(i) = R$$

Let

$$A = 2P \frac{1}{\Lambda} \beta \int_{B} \Delta X_{B,2i} dF(i) \cdot \left\{ 2\psi_{OTC} \int_{i \in T} \left( 1 - \theta \right)^2 dF(i) \right\}$$

Substituting for (2.18), we obtain

$$\tau^*_{EX} = R \cdot \frac{\psi_{EX} \int_{i \in T} \left( 1 - \theta \right) dF(i) + \psi_{EX} \int_{i \in T} \theta dF(i) + \kappa_{EX}}{\Lambda}$$

and

$$\tau^*_{OTC} = \tau^*_{EX} \left\{ \frac{\psi_{EX} \int_{i \in T} \left( 1 - \theta \right) \theta dF(i) + \psi_{OTC} \int_{i \in T} \left( 1 - \theta \right)^2 dF(i) + \int_{i \in T} \left( 1 - \theta \right) dF(i) \kappa_{EX}}{\psi_{OTC} \int_{i \in T} \theta \left( 1 - \theta \right) dF(i) + \psi_{EX} \int_{i \in T} \theta^2 dF(i) + \int_{i \in T} \theta dF(i) \kappa_{EX}} \right\}$$

The intermediate steps are derived in Appendix section 2. In this case (omitting externalities/rents), both tax rates will be optimally zero whenever the government revenue requirement $R$ is zero. Given a target revenue level $R$ and elasticity parameter estimates corresponding to $\psi_{EX}, \psi_{OTC}, \kappa_{EX}, \kappa_{OTC}$, equation (21) can thus be used to derive specific policy-relevant recommendations of optimal FTTs given a segmented market/multiple trading platforms.

In contrast to section 2.2, $\epsilon_{turnover}$ corresponds empirically to the respective market’s lock-in effect only, excluding anticipation effects, in order to emphasize that for mid-range values of market share the optimal tax ratio is less than 1, given a negligible observed lock-in effect OTC, compared to a sizable permanent decline in trading on-exchange. In other words, because OTC trading is empirically less elastic in the long-run in the absence of tax arbitrage opportunities, standard efficiency demands a relatively higher tax rate on those transactions.
2.4 Conclusion

Both the analyses in sections (2.2) and (2.3) suggest that abstracting from any considerations for externalities or rents in a particular market, optimal Ramsey taxation of multiple substitute assets/single asset in a fragmented market is well approximated by an inverse elasticity rule, weighted by the relative size of each taxed market. Furthermore, within the current framework, temporary and permanent transaction retiming elasticities are needed in combination with asset price and market structure elasticities to obtain optimal tax rates. Although not explicitly addressed in this paper, this analysis should be easily extended to a similar setting where investors face the same type of optimization problem (conditional on individual endowment shocks and return on past investments), and assets are considered close substitutes - such as equity derivative markets. Nonetheless, further research would be merited to ascertain whether these results would carry over to a setting with different asset clienteles (such as bond versus equity holders), or different optimization problems (for example, algorithmic trading versus fundamental analysis trading by human investors). Furthermore, it is important to emphasize that the presence of externalities unaccounted for explicitly in this paper could alter the optimal tax formulas both quantitatively and qualitatively; there is thus scope for future research to extend the present work by incorporating measures of externalities that may introduce Pigouvian correction concerns into the simplified Ramsey problem described here.

In conclusion, the present paper aimed at providing closed-form formulas for an optimal linear FTT under CARA preferences and normally distributed shocks in a dynamic, multi-market environment. I have taken a sufficient statistic approach, directly linking the theoretical solutions to empirically measurable parameters. Moreover, I have shown that as taxation of hedging instruments for investors facing idiosyncratic risk, financial transaction taxes can induce sizable first-order welfare losses to market participants. This “uninsurance” effect contrasts to the more often discussed role of taxation as social insurance (Varian (1980)). Alternative forms of financial sector taxation based on institutional assets or “supranormal” profits without symmetric loss offsets, by not distorting underlying portfolio hedging choices, are likely not subject to this type of deadweight loss. To the extent that those alternatives enable full taxation of pure profits and market structure rents, Diamond and Mirrlees (1971a)’s production efficiency theorem may apply, implying no equity improving role for financial transaction taxes.

Notwithstanding, a truly comprehensive study of optimal FTT design requires tackling several other aspects of capital markets’ structure intentionally omitted here for simplicity - including limit versus market orders, multiple asset types and clienteles, different margin costs of entering economically equivalent transactions, and
liquidity providers/market-makers. In addition, the present paper does not speak to the welfare implications of transaction taxes relative to or in interaction with other types of taxes (such as capital and dividend taxes, FATs (Keen et al. (2010)) or corporate taxes), including the often neglected possibility of fiscal externalities. Likewise, it abstracts from the role of asymmetric bargaining power in the actual incidence of the tax burden\footnote{For more on bargaining effects on transaction tax incidence see Kopczuk and Munroe (2015).} for OTC transactions, or any other institutional characteristics (such as fund management) that would mitigate the incidence of the tax on on-exchange traders. Finally, while the formulas derived here can be useful in assessing optimal rates from a revenue-raising perspective, they have left open the question of to what extent FTTs may have merit as instruments of Pigouvian correction for perceived financial market failures - such as excessive systemic risk taking, excessive leveraging, and negative externalities arising from asymmetric information, opaque OTC trading and algorithmic/high-frequency trading. Incorporating such corrections into the key formulas in this paper could likely increase the optimal FTT rates for certain assets/markets, but before that can be credibly achieved, further quantitative research is necessary in measuring the magnitude and core structural channels for these externalities.
In simulating the demand curves above, I imposed $A = 1$, $X_0 = 1$, $\text{Cov}_i [Z_{2t}, D] = \text{Cov}_i [Z_{3t}, D]$, $E_{ti} (D) = 100 \forall t$, $\text{Var} [D] = 16$ and the set of net buyers be the same in all periods.
Deadweight loss from the introduction of a small linear tax in a single market. A revenue-generating tax by definition implies no individualized tax rebates, suggesting a first-order deadweight loss.
CHAPTER 2. DYNAMIC AND CROSS-PLATFORM OPTIMAL FINANCIAL TRANSACTION TAXATION

Figure 2.4: Laffer curve for single exchange FTT

Laffer curve for revenue-maximizing linear transaction tax in a single market.
Figure 2.5: Optimal $\tau_{EX}^*$ given $\tau_{OTC}^*$ for different OTC market shares ($\theta_2$)

Optimal $\tau_{EX}^*$ for $\tau_{OTC}^* \in [0, 1]$ and $\int_{i \in B} 1 \text{d}F(i) \in \{\frac{1}{3}, \frac{1}{2}, \frac{2}{3}\}$.
This figure shows a simulated \( \frac{\tau^{*}_{EX}}{(1-\tau^{*}_{EX})} / \frac{\tau^{*}_{OTC}}{(1-\tau^{*}_{OTC})} \) ratio for a range of initial OTC market shares \( \in [0, 1] \). Holding \( \tau^{*}_{OTC} \) constant, \( \tau^{*}_{EX} \) is decreasing in the initial OTC market share \( \int_{i \in B} \mathbb{1}_2 dF(i) \).
Chapter 3

Fiscal Stimulus in a Monetary Union: Evidence from Eurozone Regions

3.1 Introduction

Divergent estimates of government spending multipliers (Giavazzi and Pagano (1990); Ramey (2011); Blanchard and Perotti (2002); Fatas and Mihov (2001); Hall (2009)), have historically resulted in large part from i) the difficulty in finding precisely measured exogenous changes in government spending, and ii) disentangling the contemporaneous effects of confounding variables such as tax increases or tighter monetary policy. Recent contributions to this literature have tried to circumvent some of these traditional obstacles by focusing either on estimating state-dependent multipliers (Auerbach and Gorodnichenko (2012, 2013)), or on government spending at lower levels of aggregation, using shocks to subnational spending in the US (Chodorow-Reich et al. (2012); Nakamura and Steinsson (2014)) and Japan (Bruckner and Tuladhar (2011)). This paper fits in the latter line of literature by extending the estimation of the open economy relative multiplier à la Nakamura and Steinsson (2014) to the European Union\(^1\). I do so in particular by using shocks to the supply of federal transfers to EU subnational regions as instruments of exogenous changes in local government spending.

There is also a growing parallel literature that has attempted to measure the effect of European structural and cohesion funds on regional growth and employment (Mohl and Hagen (2011, 2010); Becker et al. (2010, 2012, 2013)) and more broadly

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\(^1\)A priori, one could expect these multipliers to be different in the US and Europe due to non-trivial differences in institutional constraints and characteristics of financial services, goods markets and labor mobility, for example.
to assess the welfare gains from a redistributive fiscal union in Europe (Bargain et al. (2013); Economides et al. (2016)). Sala-i-Martin (1996) initiated the debate by finding no evidence of improved growth or convergence in EU regions by looking at the combined Structural Funds Programme. However, thereafter most empirical findings have lent support to an average positive impact of spending on per capita GDP growth (Beugelsdijk and Eijffinger (2005); Ederveen et al. (2006); Becker et al. (2010); Mohl and Hagen (2011)), alongside inconclusive employment effects. Moreover, the effects are often heterogeneous across funding categories and regions (Mohl and Hagen (2011); Becker et al. (2012, 2013); Mohl and Hagen (2010)), as are the magnitudes and even signs of the corresponding multipliers. Nonetheless, this literature has remained largely at the margin of the existing fiscal multiplier literature in the US. This paper bridges the two sets of research, by explicitly considering fiscal multipliers across different states in the context of regional structural transfers in Europe. Furthermore, this paper distinguishes itself methodologically from the latter strand of papers by using an instrumental variable approach to identify exogenous (government) supply-driven shocks to federal transfers. Becker et al. (2010) explore a regression discontinuity design within a binary treatment framework to estimate the impact of receiving structural funds aggregated by programming period for 1994-99 and 2000-06 at the NUTS 3 level (more disaggregated than the level used in this paper), while Becker et al. (2013) estimate dose-response functions (to treatment intensity) through generalized propensity scores using the same underlying data. Notably, the latter paper is able to estimate heterogeneous treatment effects across regions (rather than just a local average treatment effect at the threshold). For comparison, I also replicate the regression discontinuity strategy in Becker et al. (2010) using my preferred instrumented treatment variable in section 3. However, both strategies miss time-variant information, which is captured in Mohl and Hagen (2011), as well as in the panel IV estimates which constitute the core contribution of this paper. Finally, to the best of my knowledge, no other paper has yet used data from the recent financial and sovereign crisis period 2007-13 - a period for which understanding the response of regional macroeconomic outcomes to fiscal stimulus is particularly valuable, but also bound to exhibit exceptional characteristics. I find an average 1.72 contemporaneous open economy relative multiplier on output growth

\footnote{NUTS stands for Nomenclature des Unités Territoriales Statistiques used by Eurostat. At their most aggregated level (NUTS 1) they roughly correspond to Germany’s Bundesländer with an approximate minimum of 3 million people; NUTS 2 range between 800,000 and 3 million people, with NUTS 3 comprising the smallest of the aggregates, equivalent to French Départements. Currently there are a total of 97 regions at NUTS 1, 271 regions at NUTS 2 and 1303 regions at NUTS 3 level.}

\footnote{After adjusting the estimated coefficients of interest for co-financing of 40% on average by
for the poorest regions\(^4\), larger than those previously identified in the literature. Three years after the shock, I find a cumulative multiplier of 4.04. In addition, this large effect is fully explained by increased compensation of currently employed workers. In line with the findings of Auerbach and Gorodnichenko (2012), my estimates suggest output multipliers were larger post-2006. Finally, with the exception of two and three-year horizons post-2006, I find no significant effects on unemployment.

The results of this paper are particularly pertinent from a policy perspective to understand the potential impact of large public investment programs aimed at stimulating specific incipient economic sectors (such as renewable energy), the restructuring of existing economic activity with the collaboration of private investors to improve regional productivity (such as small and medium enterprise support and R&D), or infrastructure development. In the first half of 2015, the European Commission and the European Investment Bank have established a European Fund for Strategic Investments (EFSI), an initial €21 billion fund over a three-year period intended to garner €315 billion in additional private capital by addressing perceived existing market failures that hamper private investment in Europe (European Commission (2015)). If successful in this premise, the overall size of the program would be larger per annum than the American Recovery and Reinvestment Act of 2009.

The rationale underpinning this type of program is that by passing some of the project risk onto public institutions (effectively partially insuring idiosyncratic risky returns), public capital injections can attract private investors to projects that would otherwise not have access to credit. However, the extraordinarily high private-public leverage ratio of 15 to 1 has drawn ongoing skepticism. Since the focus areas for the EFSI overlap closely with those of the European Structural Funds Programme explored in this paper, the results presented here have direct applications for the evaluation and implementation of similar large-scale public investment and stimulus programs.

Finally, in section 3.5 I find that due to the small open economy nature of these regions within a fixed exchange rate regime, a significant portion of the estimated multipliers are in fact due to fiscal shocks elsewhere. This result is consistent with the findings of Auerbach and Gorodnichenko (2013) at the cross-country level, as well as with several recent studies observing that coordinated contractionary fiscal policy across closely integrated countries (such as within the Eurozone) could in fact be self-defeating even in models in which a unilateral contraction was expansionary, due to offsetting current account spillovers between regions (Holland and Portes (2012)).

\(^4\)Those under Objective 1 of the Cohesion Policy.
3.2 Background and data: European Regional Convergence Funds

In order to promote economic and social cohesion in the European Union, more than 35% of the Union’s budget is transferred to the less-favored regions. These include regions lagging behind in development, undergoing restructuring or facing specific geographical, economic or social problems. There are three mutually exclusive schemes under this program: Objective 1 or Convergence Objective, aimed at the development and structural adjustment of the poorest regions in Europe; Objective 2 (now Regional Competitiveness and Employment objective) is intended to assist in the socio-economic convergence of declining industrial regions and rural areas; and Objective 3 (now European Territorial Cooperation objective) supports the modernization of education, training and employment policies in regions not covered by Objective 1. (European Commission (2010)) In this paper, I focus exclusively on regions covered under Objective 1 and 2 transfers. Combined, they account for the lion’s share of expenditures under the Structural Funds Programme. NUTS 2 level regions are eligible to receive Objective 1/Convergence funds if their average GDP per capita in purchasing power parity terms (PPP) in the preceding years falls at or below 75% of the EU-wide average. The funds involved in these programs are substantial. The budget for the EU Cohesion Policy is roughly one third of the total EU budget, €347.41bn for the planning period 2007–2013. In the same period, the Convergence objective alone amasses a total of €264bn. Furthermore, by the principle of additionality, EU assistance is required to be additional to national funding and not to replace it - member states must maintain their own public expenditure at least at the level it was at in the preceding period. Hence, a priori, the effect of these funds should be felt directly through program expenditures rather than through availability of additional fiscal reserves for the national states. In terms of policy areas, most of the operational programs utilizing these funds consist of public investment in infrastructure and purchases of goods and services/subsidies/credit to private enterprises in fields such as environment and competitiveness (R&D, communication).

In practice, the physical movement of funds from the Union to the member states is done through reimbursement of certified expenditures to the final beneficiaries (which can be either public or private bodies). Most ERDF/CF assistance is granted in the form of non-repayable grants or "direct aid", and to a lesser degree refundable aid, interest-rate subsidies, guarantees, equity participation, and participation...
CHAPTER 3. FISCAL STIMULUS IN A MONETARY UNION: EVIDENCE FROM EUROZONE REGIONS

in venture capital. The timeline of transfers involves first a commitment of a given amount of funds to a NUTS 2 region during a programming period; this constitutes an upper bound on the actual amount eventually received by regions, and unofficial guidance figures for commitments are also used by the European Commission (EC) in addition to the binding total programming period commitments. Total commitment allocation by member state gets decided mainly on the basis of actual need for convergence funds several years prior to implementation (i.e., lower income states get proportionally higher funds), but also on the basis of negotiations between member states at the European Council and European Commission preceding each 6-7 year program (Heijman and Koch (2011)). Hence, I can reasonably treat them as being exogenous to contemporaneous changes in regional economic variables. After these commitments are announced, local public authorities and private agents (firms or individuals) can submit project proposals to benefit from a share of these commitments. These proposals are reviewed and accepted/rejected by the European Commission, upon which project selections are made - these are project specific ceilings on fund transfers. Finally, up to the allowed project selection amount, project managers (individuals, firms or local public authorities who proposed them) will typically be reimbursed for realized expenditures after they are incurred. The last two steps in the transfer process are thus driven by aggregate demand conditions, and thus likely respond endogenously to regional business cycle conditions. Orthogonally to business cycle fluctuations, a surprisingly large percentage of committed funds are left on the table every programming period (as much as 50% in some regions) - a reflection of low absorptive capacity (Becker et al. (2012)) -, which also weakens the link between original commitment allocations and final expenditures reimbursed.

In addition, the funds allocated to each project almost always require some degree of co-financing by either national/local authorities or private agents. For example, the expansion of the port of Augusta (Italy) channeled a €119.5m total investment, out of which 29.9% was financed by the European Regional Development Fund; in turn, the conversion of an industrial site in Caceres (Spain) into a green community space and small enterprise workspace represented a €5.5m investment, out of which 75% was financed by the EU. Thus, access to non-EU forms of funding is a necessary condition for the implementation of these projects and associated transfers. This factor may influence the magnitude of the fiscal multiplier - directly, in that the federal expenditure “shock” used in the multiplier estimation must be adjusted upwards to reflect the true extent of any project-related expenditures, but also indirectly, in that regions undergoing a contraction in financial intermediation services may have asymmetric difficulty in successfully applying for or completing projects, and their influence in regional business cycle dynamics may be curtailed due to a financial accelerator effect (Bernanke et al. (1999)).
I use data on total amount of funds committed to and spent in NUTS 2 regions for each year of programming periods 2000-06 and 2007-13\(^7\). The data was generously provided by the Directorate General for Regional Policy of the European Commission. Importantly, while data on commitments by region was available on an annual basis over 2000-2013, data on expenditures at a NUTS 2 level was only available by programming period total. Therefore, I imputed annual expenditure amounts by NUTS 2 by assuming that the year-on-year evolution of regional expenditure follows the same pattern (in percentage terms) as the evolution at the national level. In other words, within a 6 year programming period (PP), if 20\% of the total corresponding expenditure at the national level occurred in year 1 of the PP, then I input 20\% of the total PP expenditure in a given region in that country to year 1, and so forth for every region and year. In addition, since expenditures relating to projects selected during the 2000-06 PP carry on well into the 2007-13 period, during the latter years I use not only actual annual EC commitments for the respective year in the 2007-13 PP as instruments, but also a counterfactual “remaining commitment” from 2000-06, which I construct by subtracting the sum of all realized expenditures until 2006 from the overall PP commitment, and geometrically reducing the net amount until 2013. Years from 2007 onwards thus use a “combined” two-part instrument, although I treat it as a single instrument in all estimates below. Hence, the key sources of variation in expenditure I am using in this paper are both the cross-section of NUTS 2 regions within each programming period, and annual changes across countries. In contrast, my core instrument (commitment) varies both at the cross-sectional and time series levels. Though there exist data on total expenditures for the 2000-06 programming period by NUTS 3 region\(^8\), the lack of any comparable data for 2007-13 prevents us from using this level of disaggregation (which would have quadrupled the sample size). Furthermore, since commitments are determined at the NUTS 2 and not NUTS 3 level, my first stage IV strategy is naturally constrained to variation across NUTS 2 regions and over time. Data on GDP components, population, unemployment rates and business structural indicators is taken entirely from Eurostat. Figure 3.1 depicts the geographic incidence of these funds over two years in the sample, and Table 3.1 summarizes mean descriptive statistics by country. It is immediately apparent that structural funds are highly concentrated in “periphery” regions of the European Union, but even within these there is considerable variation in their proportion to local GDP over time. Note despite many regions receiving a relatively small share of funds, all regions receive a strictly positive amount from

\(^7\)There are printed sources for annual regional commitments and expenditures 1994-99, which can be used to expand the current database going back 5 years. TBC

\(^8\)Sweco ex-post consulting report to the European Commission
3.3 Fiscal shock identification strategy

As described in the previous section, due to the demand-driven nature of EU structural funds, annual fund expenditure across regions (or annual changes in this variable) is not an exogenous measure of a shock to regional fiscal policy. However, it is still our key variable of interest, in the sense that (excluding anticipatory effects) in theory shocks to federal transfers should affect regional outcomes once they are actually realized. In this paper, I propose using the original EC fund commitments as instruments for the actual expenditure realized. The former are highly predictive of ultimate expenditures, but are exogenously determined with respect to contemporaneous business cycle conditions, satisfying one of the critical identification assumptions for the estimation of fiscal multipliers mentioned in the introduction. This instrumentation is the most significant methodological difference between this paper and the most recent contributions to the structural funds impact evaluation literature (Mohl and Hagen (2011); Becker et al. (2010)). Using actual payments to regions as the explanatory variable without correcting (as suggested by this paper) for endogeneity with respect to regional business cycle conditions can lead to ambiguous biases in multiplier estimates. On the one hand, it could lead to an upward bias in the spending multiplier if an expansion in GDP is positively correlated with a rise in aggregate demand that boosts applications for EU co-funded projects. On the other hand, it could also lead to downward bias if there is substitutability between private/local public financing sources and European funds, such that more financing-constrained firms in recessions would need European funds more than during expansionary periods, and as such absorb a greater share of available commitments on the table. Finally, instrumenting for expenditures using commitments also allows us to attenuate some of the measurement error present in the construction of our annual expenditure series, given the data on commitments by year and region is more accurately collected than ultimate expenditures (whose reporting and verification is typically under the responsibility of different national and local authorities, often with little accountability towards the European Commission).

Furthermore, although I do not deal exclusively with regions within the Eurozone, I argue that I am able to maintain monetary policy and nominal interest rates constant, since the vast majority of other EU members in my sample have domestic currencies closely pegged to the Euro throughout the estimation period, and most are scheduled to join the currency union in the near future (so I can expect their

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9With the exception of the United Kingdom.
monetary policy to be aligned with the ECB’s). As shown in several tables below, restricting our attention to Eurozone-only countries does not alter any of the results presented here. Moreover, while tax policy is not common across all regions, this variable should not be confounding in the traditional sense since EU funds are agreed ex-ante for 6-7 year plans, and the corresponding revenues needed to support them are pre-arranged during supranational negotiations years before the actual spending comes into effect at the regional level. Furthermore, member state contributions to the EU budget serve several other budgetary allocations beyond regional convergence (including agricultural subsidies, administrative expenses, etc), so their original incidence should also not be directly associated with ERDF disbursements.

Similarly to Nakamura and Steinsson (2014), I use

\[ G_{t} - G_{t-1} \]

as my main explanatory variable capturing the fiscal shock\(^{10}\). This facilitates the direct interpretation of both the panel estimation coefficient and the regression discontinuity local average treatment effect as multipliers.

### 3.4 Panel instrumental variables estimation

In the core section of this paper, I replicate Nakamura and Steinsson (2014) in a two-step instrumental variable dynamic panel estimation setup, where as previously mentioned, I use changes in annual commitments to EU regions as instruments for changes in annual expenditures in those regions associated with EU structural funds transfers:

\[
\frac{Y_{i,t+h} - Y_{i,t-1}}{Y_{i,t-1}} = \alpha_{j,h} + \gamma_{t,h} + \beta_h \frac{G_{i,t} - G_{i,t-1}}{Y_{i,t-1}} + \delta_h X_i + \rho_h \frac{Y_{i,t-1} - Y_{i,t-2}}{Y_{i,t-2}} + \epsilon_{i,h}
\]

where \(Y_{i,t+h}\) is the outcome variable (i.e., real GDP per capita growth, change in the unemployment rate) at horizon \(h = 0, 1, 2, 3\) and changes in expenditures \(G_{i,t} - G_{i,t-1}\) are instrumented using commitments \(\{C_{i,t}, C_{i,t-1}\}\) according to the following first stage

\[
\Delta G_{i,t} \equiv G_{i,t} - G_{i,t-1} = \lambda_j + \nu_t + \theta_{i,t} C_{i,t} + \theta_{i,t-1} C_{i,t-1} + \mu X_i + \zeta_i
\]

Instrumenting for changes in expenditures using contemporaneous and lagged levels (rather than the change) of commitments enables more flexible weighting on each

\(^{10}\)Note that Nakamura and Steinsson (2014) use a two-year cumulative shock, rather than annual.
component of the change, and is supported by stronger first stage relevance. I define the key government spending shock variable as \( \Delta G_{i,t} \) in the baseline specification for comparability with the fiscal multiplier literature using domestic US data (Hall (2009); Serrato and Wingender (forthcoming); Chodorow-Reich et al. (2012); Nakamura and Steinsson (2014)), which commonly defines spending shocks as first (or second) differences due to the persistence of government spending levels. In contrast, existing literature studying the impact of European structural funds using dynamic panel data models typically uses levels of funds (either lagged or contemporaneous) as the key explanatory variable of interest (Ederveen et al. (2006); Mohl and Hagen (2010, 2011)). This choice is also common in the literature examining the effects of foreign aid on developing countries (Clemens et al. (2004)). In order to bridge these two strands of literature, in Table 3.10 I run the same set of core regressions using \( G_{i,t} \) as the key explanatory variable of interest. However, since \( G_{i,t} \) has high serial correlation within each region, I add lags \( \sum_{s=1}^{L} G_{i,t-s} \), where \( L \) corresponds to the measured order of autocorrelation, in order to capture otherwise omitted variable effects of previous lags in spending on current output growth.

Due to my imputation of annual changes in expenditures from the national to the regional level, I cannot use region-specific fixed effects. To compensate for this, I use both country fixed effects \((\alpha_j, \lambda_j)\), and values of region-specific control variables \(X_i\) (average years of education, share of employment in manufacturing/industry, and share of employment in the public sector) at the beginning of the sample period. I also include year fixed effects \((\gamma_t, \nu_t)\). Maximizing likelihood of fit according to BIC, I include only one lag of the outcome variable on the right-hand side. Regional GDP components and federal transfers are deflated using annual national inflation. Standard errors are clustered at the regional level. I also exclude a few outlier GDP growth region-year observations. Figure 3.2 illustrates the relationship between key first stage variables for Objective 1 regions in a representative year. There is a strong linear positive correlation between committed and ultimately contemporaneously spent funds, with the lack of full absorption of commitment ceilings evident from

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11 Instrumenting for \( \Delta G_{i,t} \) using net \( C_{i,t} - C_{i,t-1} \) implicitly imposes an equal weight on \( C_{i,t} \) and \( C_{i,t-1} \).

12 Doing so would eliminate most of the cross-sectional variation between NUTS 2 regions, since these only vary by programming period and not by year, except insofar as their home state pattern also changes.

13 Their values in 2000.

14 Unfortunately, given the short span of our time series, I cannot use Driscoll-Kraay HAC standard errors; for consistency, these need \( T > 20 - 25 \).

15 In particular, I exclude EE 2009/2011, LT 2009/2010, as well as SE33 2010 (abnormally sharp growth/recession and very low transfers change), and ES61 2010 (abnormally large increase in transfers); UKF1 (2009/2010/2011), and NL11 2008.
the fact that most observations sit below the 45 degree line. Exceptions at the lower end of the spectrum where expenditures in a given year surpass the Commission’s annual commitment (such as GR3, the NUTS 2 region corresponding to Athens) are usually the consequence of carry-over commitments from previous years (i.e., projects formerly approved with expenditures incurred with a lag).

Analysis of results

In the core specifications, I find large positive statistically significant output multipliers. In addition, results seem to be persistent over time\textsuperscript{16}. Within Objective 1 regions, estimates are of larger magnitude and significance post-2006 (Table 3.2). Across the board, Objective 1 regions exhibit a large multiplier, slightly more so outside of the EU-12\textsuperscript{17} (see Table 3.4). In theory, regions outside of the EU-12 could be at a developmental disadvantage compared to older member states, ridden with institutional characteristics that would jeopardize their efficient absorption of the federal funds into the local economy, as some studies have suggested fiscal multipliers to be substantially smaller in developing countries than in industrialized ones (Ilzetzki et al. (2013)); notwithstanding, my results do not seem to corroborate such a hypothesis. Overall, the estimated open economy relative multipliers are larger than most of those found by the literature, as well as more immediate (Mohl and Hagen (2010) only find effects with a 4-year lag, for instance). Part of the explanation for the magnitude of the multipliers found has to do with the fact that due to co-funding in the order of 40\% by local authorities or private agents, I am effectively underestimating the explanatory fiscal shock (and thus inflating the true multiplier). Adjusting for this matching requirement, the contemporaneous expenditure multiplier is 1.7 in the main specification for Objective 1 regions, and cumulatively 4 over the course of three years. Moreover, as an open economy relative multiplier, it encompasses spillover effects from shocks to nearby regions, as well as regions economically closely linked. I deal with the estimation of spillovers in more detail in section 3.5.

In addition, in line with both Mohl and Hagen (2011) and Becker et al. (2010), I do not observe a statistically significant effect on unemployment in most specifications. A noteworthy exception to this are large and significant negative multipliers on unemployment in Objective 1 regions post-2006. A combination of liberalizing labor market reforms in countries affected by sovereign rescue plans (making it cheaper to both fire and hire workers temporarily) and the slackness of the labor market post-2010 may have contributed to this effect. One possible explanation for

\textsuperscript{16}Rather than hump-shaped as in Blanchard and Perotti (2002).

\textsuperscript{17}The original Eurozone member states.
the large but isolated negative contemporaneous unemployment effect for Objective 2 regions (Table 3.6) could be that short-duration retraining programs (more commonly encompassed under Objective 2) temporarily reduce reported unemployment. Florio and Moretti (2014) also suggest there may be significant heterogeneity across industries underlying aggregate estimates such as the ones presented in this paper.

Moreover, I find non-significant effects of transfers on output growth for objective 2 regions (Table 3.3). Mohl and Hagen (2010) find negative effects for Objective 2 funds on GDP (looking exclusively at EU-15). Out of the reasons proposed by the authors for those findings, the one most consistent with my findings is the existence of some crowding out of local public investment. In particular, I cannot reject the hypothesis that structural funds are being used to indirectly reduce public deficits, nor of crowding out of private investment itself. Furthermore, diversion of private investment and government spending to cross-border projects where growth stimulus is going to be counted in neighboring regions may be more pronounced if Objective 2 regions are more open to trade than Objective 1 regions, causing them to ceteris paribus lose in spillovers (Ilzetzki et al. (2013)), since conditional on fixed exchange rates, in theory greater trade openness leads to smaller measured multipliers (Nakamura and Steinsson (2014)); this is plausible since most of the negatively affected regions are relatively more central geographically.

Furthermore, across almost all specifications with output growth, investment and wages as the dependent variable, I find evidence of mean-reversion. This is however not the case for regressions with unemployment change as the dependent variable - which attests to the presence of hysteresis. Negative autoregressive coefficients, especially at short lags, are consistent both with greater measurement error in regional economic series, and with frequent asymmetric shocks and higher specialization at the regional level, corroborated by the literature on regional business cycles in Europe (De Grauwe and Vanhaverbeke (1991)). Furthermore, it is also consistent with the downward bias of fixed effect estimation of a dynamic panel model (Nickell (1981)). Excluding this lagged outcome variable from our estimations does not affect the key multiplier results.

Finally, I run a series of robustness tests of the results from the baseline specification. The first column of Table 3.2 regresses \( \frac{Y_{i,t+1} - Y_{i,t-2}}{Y_{i,t-2}} \) on \( \frac{G_{i,t} - G_{i,t-1}}{Y_{i,t-1}} \) (in words, the first-lag of the dependent variable on the federal expenditure shock at time \( t \)), in order to capture any measurable anticipation effects. Given the significant degree of autocorrelation of the outcome variable series, it is theoretically possible that anticipatory effects could partially explain the high multipliers I find in the baseline results, thereby reducing their contemporaneous magnitude. This possibility is consistent with the persistent and potentially predictable magnitude of these transfer
programs in practice, which could induce private firms, households, and local governments to expand their investment and consumption patterns in anticipation of future funds, thereby increasing contemporaneous and future growth rates. However, as shown in column 1 of Table 3.2, I find no evidence that is the case. Econometrically, this result also mitigates the concern that my definition of a right-hand side variable “shock” as the year-on-year change in expenditures to GDP might not be a true “shock” in the sense of being exogenous and not anticipated by economic agents. In addition, Tables 3.10, 3.11, and 3.12 provide estimates over the core sample and specification using alternative measures of either the regressor of interest, the dependent variable, or standard errors. Table 3.10 replicates the baseline estimation for Objective 1 regions using actual expenditure levels instead of changes as the key shock of interest. There are non-trivial differences in the results. In particular, while the multiplier for the entire sample period is in fact positive and even larger than that found using changes as a measure of fiscal shock, it is not statistically significant in post-2006 years. A possible explanation for this discrepancy could be the relatively poor macroeconomic performance of regions in sovereign-debt crisis ridden countries post-2008, which were also highly dependent on European Cohesion Funds on a level basis (thus a sample selection artifact). It is also difficult to disentangle what the counterfactual decline in output growth and employment would have been absent these expenditures, so the absence of a significant effect under this specification should not be taken as conclusive evidence of the lack of a positive stimulus effect. Furthermore, as mentioned earlier in the paper, the sharp contraction of financial intermediation services during the sovereign-debt crisis in Southern Europe and Ireland could have also hampered an important transmission channel of the multiplier. Table 3.11 uses the same definition of the shock variable on the right-hand side as the baseline specification (year-on-year changes), but replaces year-on-year actual GDP growth on the left-hand side with the output gap, defined as $\frac{Y_{t+h} - Y_{Potential}}{Y_{Potential}}$, where $Y_{Potential}$ is the trend predicted outcome at time $t$. The baseline results are fully maintained using this outcome definition. Lastly, Table 3.12 presents the core estimates using Driscoll-Kraay standard errors in the second-stage of the panel IV, which are less conservative than the region-clustered standard errors.

Narrowing down the aggregate effects to specific GDP components, the core driver of the large contemporaneous fiscal multiplier from an income approach seems to be changes in aggregate compensation to employees (entitled “wages” in the Table 3.8). Since data on hourly wages by region is not available, I include employment changes per population as an additional outcome variable. There does not seem to be a similar response by employment, suggesting most of the increase in compensation of employees is absorbed by increases in wages to existing workers, rather than new job creation. These results are consistent with a New-Keynesian model with both
frictional unemployment and downward real wage rigidities, where a positive demand shock leads to countercyclical price markups.

Ideally, I would like to have a decomposition of GDP into all of its parts - in particular including consumption. Unfortunately, consumption cannot be included as an explicit component since the expenditure approach to GDP accounting is not used in the EU at the regional level (due to lack of collection of regional net export data). However, as an alternative I use disposable household income\textsuperscript{18}.

Note that the impact on compensation of employees substantially surpasses that on overall GDP, especially in longer horizons, suggesting an offsetting negative effect on some other GDP component. Since no other of the components included in Table 3.8 quantitatively or qualitatively reveals such a negative effect, it is likely that a deterioration of regional current account positions (possibly following an increase in relative labor costs) could reconcile these results.

### 3.5 Cross-regional spillover effects

From a theoretical perspective, the existence of spillover effects of one region’s spending on another’s outcomes could lead to an underestimation of the true aggregate federal effect of regional government expenditures, if that spillover were positive. This scenario could be supported by an increase in import demand from the region receiving the positive expenditure shock (an aggregate demand story - Serrato and Wingender (forthcoming)) or by technological/knowledge/human capital transfers to interconnected regions in cases where government expenditures spur productivity improvements. The latter transmission channel is likely to be more relevant over non-contemporaneous horizons, as productivity-driven dynamics typically respond to public investment shocks with longer lags due to learning, research and time-to-build delays (Alston et al. (2010)). Alternatively, negative spillovers could theoretically arise due to labor market competition among regions, for example, leading to an overestimation of the aggregate closed economy multiplier from the baseline domestic multiplier figures in Table 3.2. From a policy perspective, determining the existence of spillover effects fits within the discussion of transnational fiscal stimuli in light of the recent sovereign-debt crisis in Europe. In particular, in the presence of positive spillover effects and asymmetric business cycle conditions in different regions, a region with room for fiscal expansion and an accommodative monetary policy stance could choose to do so in order to stimulate import demand from a debt-constrained region undergoing a demand-driven recession - for example, Germany expanding its

\textsuperscript{18} Assuming a constant MPC across the business cycle, consumption and disposable income series should track each other closely.
CHAPTER 3. FISCAL STIMULUS IN A MONETARY UNION: EVIDENCE FROM EUROZONE REGIONS

fiscal stance in order to boost Greece’s current account position post-2010 (Elekdag and Muir (2014); Blanchard et al. (2015)).

The European Union does not have inter-regional bilateral trade surveys similar to the ones the US and Canada have conducted in recent decades. The closest existing matrix of bilateral trade between NUTS 2 regions in Europe is by Thissen et al. (2013), who constructed a social accounting matrix with the most likely trade flows between European regions consistent with national accounts. Using the ratio of import flows between regions as weights for spillover shocks (akin the methodology proposed by Auerbach and Gorodnichenko (2013)), I get the results in Table 3.9. In particular, I have created a bilateral trade weighted fiscal shock variable to estimate the impact of cross-regional spillovers. I first predict the instrumented own-region shock for every region and year (expenditure change instrumented by commitment change). Then for each region $j$, I compute a weighted average of fiscal shocks of other regions $k$ (excluding own-shock), weighted by the share of total imports by region $k$ coming from $j$ (so that the sum of weights is always $< 1$). The second stage uses this trade-weighted shock variable as the key regressor, and standard errors are bootstrapped with resampling within region clusters to account for the measurement error induced by the estimated regressor in the first stage. The results are positive and significant up to the third horizon after a shock. Notice they are contemporaneously larger than own-shock multipliers, but in contrast to the latter, these results suggest spillover effects fizzle out over time, rather than accumulate. This is consistent with the existence of positive demand spillovers, and can be reconciled with the positive own-shock multipliers I find in this paper.

3.6 Conclusion

Using novel data on regional structural funds transfers from the European Commission, this paper provided empirical estimates of an open economy relative fiscal multiplier for the European Union. I proposed a solution to a key endogeneity concern pervasive across studies looking at the efficacy of these transfers as a form of fiscal stimulus, involving the use of internal annual commitments/targets by the federal authority as instruments for the actual expenditures (endogenous to local macroeconomic conditions, but also our shock variable of interest). I found a very large multiplier in the order of 1.7 contemporaneously and 4 cumulatively over a three-year period, suggesting there may be room for welfare improving redistributive fiscal transfers across European regions. In addition, I used a novel dataset on constructed bilateral trade flows between European Union regions to estimate the magnitude of what I found to be equally large (though dynamically different from
domestic multiplier) spillover effects across regions.

However, this paper refrained from speaking to what are likely to be increasingly important differences in effectiveness of heterogeneous types of transfers - either across industrial sector composition, beneficiary characteristics, project objectives, or the institutional environment of the recipient region. More EU-wide micro-oriented analyses of the impact of federal public investments on specific beneficiary companies’ employment and profitability performance relative to that of comparable non-beneficiaries (along a similar path to that blazed by Greenstone et al. (2010) and Florio and Moretti (2014) should provide micro-founded evidence capable of reconciling some of the core aggregate findings presented here. Likewise, expansion of the present analysis to longer time periods for which detailed financing records exist may facilitate future research into the state-dependence of the core fiscal multipliers and spillover effects described.
## Chapter 3. Fiscal Stimulus in a Monetary Union: Evidence from Eurozone Regions

Table 3.1: Summary Statistics All regions (NUTS 2 level), 2000-2011

<table>
<thead>
<tr>
<th>Country</th>
<th>Total NUTS2 Region Count</th>
<th>Obj. 1</th>
<th>Obj. 2</th>
<th>Expenditure to GDP (%)</th>
<th>Committed Funds to GDP (%)</th>
<th>GDP Growth (%)</th>
<th>Unemployment Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>9</td>
<td>1</td>
<td>8</td>
<td>0.08</td>
<td>0.11</td>
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<td>4.24</td>
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<td>0.07</td>
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<td>7.82</td>
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<td>CY</td>
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<td>1</td>
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<td>0.22</td>
<td>1.82</td>
<td>6.10</td>
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<tr>
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</tr>
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<td>13</td>
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<td>0.40</td>
<td>-0.35</td>
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</tr>
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<td>1.35</td>
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<tr>
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<td>1.59</td>
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<td>1.93</td>
<td>7.12</td>
</tr>
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<td>0.59</td>
<td>0.08</td>
<td>6.68</td>
</tr>
<tr>
<td>SK</td>
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<td>3</td>
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<td>0.58</td>
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<tr>
<td>UK</td>
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<td>0.07</td>
<td>0.12</td>
<td>1.43</td>
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<tr>
<td>Total</td>
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<td>105</td>
<td>133</td>
<td>0.36</td>
<td>0.68</td>
<td>1.32</td>
<td>8.98</td>
</tr>
</tbody>
</table>

Number of regions with no missing data.
Obj.1/2 categorization as of 2006.

The last four columns represent annual averages for each country during the 2000-2011 period.
### Table 3.2: Panel IV - Objective 1 only (NUTS 2 level), 2000-2011

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Post-2006</th>
<th>All</th>
<th>Post-2006</th>
<th>All</th>
<th>Post-2006</th>
<th>All</th>
<th>Post-2006</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual shock to expenditures to GDP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Anticipation</td>
<td>0.454</td>
<td>2.962***</td>
<td>3.137***</td>
<td>4.447***</td>
<td>5.101***</td>
<td>4.670**</td>
<td>5.720***</td>
<td>6.776*</td>
</tr>
<tr>
<td></td>
<td>(0.906)</td>
<td>(0.670)</td>
<td>(0.581)</td>
<td>(1.574)</td>
<td>(1.590)</td>
<td>(2.273)</td>
<td>(1.916)</td>
<td>(3.531)</td>
</tr>
<tr>
<td>- Contemporaneous</td>
<td>-0.022</td>
<td>0.023</td>
<td>0.024</td>
<td>-0.110*</td>
<td>-0.305***</td>
<td>-0.066</td>
<td>-0.176</td>
<td>-0.140</td>
</tr>
<tr>
<td></td>
<td>(0.047)</td>
<td>(0.043)</td>
<td>(0.062)</td>
<td>(0.059)</td>
<td>(0.086)</td>
<td>(0.086)</td>
<td>(0.231)</td>
<td>(0.121)</td>
</tr>
<tr>
<td>- 1st Lead</td>
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<td>0.007</td>
<td>0.009</td>
<td>0.007</td>
<td>0.005</td>
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<td>0.001</td>
<td>-0.012</td>
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<td>(0.005)</td>
<td>(0.006)</td>
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<td>(0.009)</td>
<td>(0.011)</td>
<td>(0.012)</td>
<td>(0.015)</td>
</tr>
<tr>
<td>- 2nd Lead</td>
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<td>0.051***</td>
<td>0.018</td>
<td>0.069**</td>
<td>-0.008</td>
<td>0.001</td>
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<td>(0.012)</td>
<td>(0.018)</td>
<td>(0.025)</td>
<td>(0.031)</td>
<td>(0.040)</td>
<td>(0.050)</td>
<td>(0.055)</td>
</tr>
<tr>
<td>- 3rd Lead</td>
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<td>-0.033**</td>
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<td>-0.048*</td>
<td>-0.041*</td>
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<td>-0.025</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.008)</td>
<td>(0.014)</td>
<td>(0.016)</td>
<td>(0.026)</td>
<td>(0.023)</td>
<td>(0.033)</td>
<td>(0.031)</td>
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<td><strong>L.GDP growth</strong></td>
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<td>0.023</td>
<td>0.024</td>
<td>-0.110*</td>
<td>-0.305***</td>
<td>-0.066</td>
<td>-0.176</td>
<td>-0.140</td>
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<td></td>
<td>(0.047)</td>
<td>(0.043)</td>
<td>(0.062)</td>
<td>(0.059)</td>
<td>(0.086)</td>
<td>(0.086)</td>
<td>(0.231)</td>
<td>(0.121)</td>
</tr>
<tr>
<td><strong>Education</strong></td>
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<td>0.009</td>
<td>0.007</td>
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<td>(0.005)</td>
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<td>(0.011)</td>
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<td>(0.015)</td>
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<td><strong>Industry share</strong></td>
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<td>0.051***</td>
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<td>0.069**</td>
<td>-0.008</td>
<td>0.001</td>
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<tr>
<td></td>
<td>(0.016)</td>
<td>(0.012)</td>
<td>(0.018)</td>
<td>(0.025)</td>
<td>(0.031)</td>
<td>(0.040)</td>
<td>(0.050)</td>
<td>(0.055)</td>
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<td><strong>Public share</strong></td>
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<td>-0.033**</td>
<td>-0.050***</td>
<td>-0.048*</td>
<td>-0.041*</td>
<td>-0.001</td>
<td>-0.025</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.008)</td>
<td>(0.014)</td>
<td>(0.016)</td>
<td>(0.026)</td>
<td>(0.023)</td>
<td>(0.033)</td>
<td>(0.031)</td>
</tr>
<tr>
<td><strong>N</strong></td>
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<td>91</td>
<td>91</td>
<td>91</td>
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<td>91</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
Includes year and country fixed effects.
Clustered s.e.s at NUTS 2 level.

The "anticipation" column presents estimates of the baseline multiplier for Objective 1 regions in the year preceding the shock, by setting the dependent variable as $Y_{i,t-1} - Y_{i,t-2}$.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

---

### Table 3.3: Panel IV - Objective 1 vs 2 (NUTS 2 level), 2000-2011

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Post-2006</th>
<th>All</th>
<th>Post-2006</th>
<th>All</th>
<th>Post-2006</th>
<th>All</th>
<th>Post-2006</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual shock to expenditures to GDP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.670)</td>
<td>(4.378)</td>
<td>(1.574)</td>
<td>(8.252)</td>
<td>(2.273)</td>
<td>(11.926)</td>
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<tr>
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<td>-0.110*</td>
<td>-0.048</td>
<td>0.023</td>
<td>0.115***</td>
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<tr>
<td></td>
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<td>(0.087)</td>
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<td>-0.003</td>
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Standard errors in parentheses
Includes year and country fixed effects.
Clustered s.e.s at NUTS 2 level.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
## Chapter 3. Fiscal Stimulus in a Monetary Union: Evidence From Eurozone Regions

### Table 3.4: Panel IV - Objective 1 regions: All vs EU-12 (NUTS 2 level), 2000-2011

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<td>All EU-12 only</td>
<td>All EU-12 only</td>
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<td><strong>Annual shock to expenditures to GDP</strong></td>
<td>2.382***</td>
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<td><strong>L.GDP growth</strong></td>
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<td>0.098</td>
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<td>(0.063)</td>
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<td>(0.005)</td>
<td>(0.003)</td>
<td>(0.008)</td>
<td>(0.011)</td>
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<tr>
<td><strong>Industry share</strong></td>
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<td>-0.050***</td>
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N: 817 585 749 542 681 499 621 455
Clustered s.e.s at NUTS 2 level.

### Table 3.5: Panel IV - Objective 1 only (NUTS 2 level), 2000-2011

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<td>All EU-12 only</td>
<td>All EU-12 only</td>
<td>All EU-12 only</td>
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<td>(0.007)</td>
<td>(0.006)</td>
<td>(0.013)</td>
<td>(0.011)</td>
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<tr>
<td><strong>Public share</strong></td>
<td>0.017*</td>
<td>0.001</td>
<td>0.041**</td>
<td>0.020*</td>
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<td>(0.011)</td>
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N: 861 517 861 517 862 517 779 433
Clustered s.e.s at NUTS 2 level.

Standard errors in parentheses
Includes year and country fixed effects.
Clustered s.e.s at NUTS 2 level.
### Table 3.6: Panel IV - Objective 1 vs 2 (NUTS 2 level), 2000-2011

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<td>0.042</td>
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<td>0.129**</td>
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<td>(0.055)</td>
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<td>(0.003)</td>
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Standard errors in parentheses
Includes year and country fixed effects.
Clustered s.e.s at NUTS 2 level.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

### Table 3.7: Panel IV - Objective 1 regions: All vs EU-12 (NUTS 2 level), 2000-2011

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<td>All</td>
<td>EU-12 only</td>
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<td>Annual shock to expenditures to GDP</td>
<td>-0.167</td>
<td>0.144</td>
<td>-0.717</td>
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<td>L.Unemployment rate change</td>
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<td>-0.002</td>
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<td>0.012</td>
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<td></td>
<td>(0.007)</td>
<td>(0.010)</td>
<td>(0.013)</td>
<td>(0.015)</td>
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<tr>
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<td>0.036***</td>
<td>0.041**</td>
<td>0.074***</td>
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Standard errors in parentheses
Includes year and country fixed effects.
Clustered s.e.s at NUTS 2 level.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Table 3.8: Panel IV - Objective 1 regions (NUTS 2 level), 2000-2011

GDP Components

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<th>Wages</th>
<th>Empl</th>
<th>GDP</th>
<th>DInc</th>
<th>Inv</th>
<th>Wages</th>
<th>Empl</th>
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<td>(0.014)</td>
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<td>-0.056**</td>
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<td>-0.056**</td>
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<td>(0.015)</td>
<td>(0.011)</td>
<td>(0.017)</td>
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<td>(0.076)</td>
<td>(0.046)</td>
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<td>(0.079)</td>
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<td>-0.004</td>
<td>-0.103**</td>
<td>0.077</td>
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<td>-0.133**</td>
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Standard errors in parentheses
Includes year and country fixed effects.
Clustered s.e.s at NUTS 2 level.
*p < 0.1, **p < 0.05, ***p < 0.01
Table 3.9: Panel IV - All regions (NUTS 2 level, all objectives), 2000-2011
Import-weighted fiscal spillovers

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<th>3rd Lead</th>
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<td>5.841***</td>
<td>1.914*</td>
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<td>(1.058)</td>
<td>(0.719)</td>
<td>(1.640)</td>
<td>(0.983)</td>
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<td>L.GDP growth</td>
<td>0.071***</td>
<td>-0.083***</td>
<td>0.091***</td>
<td>-0.035*</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.020)</td>
<td>(0.025)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Education</td>
<td>-0.003</td>
<td>0.005</td>
<td>-0.001</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Industry share</td>
<td>-0.002</td>
<td>-0.010</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.009)</td>
<td>(0.010)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Public share</td>
<td>0.012</td>
<td>0.001</td>
<td>0.007</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.010)</td>
<td>(0.008)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>N</td>
<td>2613</td>
<td>2377</td>
<td>2149</td>
<td>1956</td>
</tr>
<tr>
<td>Clusters</td>
<td>237</td>
<td>237</td>
<td>237</td>
<td>237</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
Includes year and country fixed effects.
Weighted fiscal shock measure excludes own-region shock.
Standard errors are bootstrapped with resampling within NUTS 2 level clusters.
*p < 0.1, **p < 0.05, ***p < 0.01
## Table 3.10: Panel IV - Objective 1 only (NUTS 2 level), 2000-2011
### RHS: Spending levels

<table>
<thead>
<tr>
<th></th>
<th>Contemporaneous</th>
<th>1st Lead</th>
<th>2nd Lead</th>
<th>3rd Lead</th>
<th>4th Lead</th>
<th>5th Lead</th>
<th>6th Lead</th>
<th>All Post-2006</th>
<th>All Post-2006</th>
<th>All Post-2006</th>
<th>All Post-2006</th>
<th>All Post-2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.GDP growth</td>
<td>0.099*</td>
<td>0.044</td>
<td>-0.107</td>
<td>-0.217**</td>
<td>-0.031</td>
<td>0.192</td>
<td>-0.426</td>
<td>-0.769</td>
<td>(0.055)</td>
<td>(0.059)</td>
<td>(0.082)</td>
<td>(0.094)</td>
</tr>
<tr>
<td>Education</td>
<td>0.006</td>
<td>0.010</td>
<td>0.000</td>
<td>0.001</td>
<td>-0.010</td>
<td>-0.017</td>
<td>-0.011</td>
<td>0.015</td>
<td>(0.006)</td>
<td>(0.007)</td>
<td>(0.012)</td>
<td>(0.014)</td>
</tr>
<tr>
<td>Industry share</td>
<td>0.016</td>
<td>0.061***</td>
<td>-0.025</td>
<td>0.023</td>
<td>-0.045</td>
<td>-0.068</td>
<td>-0.075</td>
<td>0.203</td>
<td>(0.015)</td>
<td>(0.023)</td>
<td>(0.038)</td>
<td>(0.066)</td>
</tr>
<tr>
<td>Public share</td>
<td>-0.032**</td>
<td>-0.041*</td>
<td>-0.034</td>
<td>-0.016</td>
<td>-0.022</td>
<td>0.055</td>
<td>-0.067</td>
<td>-0.084</td>
<td>(0.015)</td>
<td>(0.023)</td>
<td>(0.026)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>N</td>
<td>787</td>
<td>419</td>
<td>719</td>
<td>351</td>
<td>651</td>
<td>253</td>
<td>591</td>
<td>223</td>
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<td>91</td>
<td>91</td>
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<td>91</td>
<td>91</td>
<td>91</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standard errors in parentheses
Includes year and country fixed effects.
3 lags of spending levels are also included on the right hand-side to control for autocorrelation.
Clustered s.e.s at NUTS 2 level.
* p < 0.1, ** p < 0.05, *** p < 0.01

## Table 3.11: Panel IV - Objective 1 only (NUTS 2 level), 2000-2011
### LHS: Percentage output gap

<table>
<thead>
<tr>
<th></th>
<th>Contemporaneous</th>
<th>1st Lead</th>
<th>2nd Lead</th>
<th>3rd Lead</th>
<th>4th Lead</th>
<th>5th Lead</th>
<th>6th Lead</th>
<th>All Post-2006</th>
<th>All Post-2006</th>
<th>All Post-2006</th>
<th>All Post-2006</th>
<th>All Post-2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual expenditures to potential GDP</td>
<td>2.059***</td>
<td>2.398***</td>
<td>2.968***</td>
<td>2.732***</td>
<td>3.731**</td>
<td>3.134**</td>
<td>5.377*</td>
<td>5.065**</td>
<td>(0.712)</td>
<td>(0.597)</td>
<td>(1.319)</td>
<td>(1.028)</td>
</tr>
<tr>
<td>L.Percentage Output Gap</td>
<td>0.811***</td>
<td>0.821***</td>
<td>0.429***</td>
<td>0.331***</td>
<td>0.079</td>
<td>0.028</td>
<td>-0.323***</td>
<td>-0.002</td>
<td>(0.033)</td>
<td>(0.049)</td>
<td>(0.054)</td>
<td>(0.067)</td>
</tr>
<tr>
<td>Education</td>
<td>0.005</td>
<td>0.005</td>
<td>0.007*</td>
<td>0.003</td>
<td>0.007</td>
<td>-0.000</td>
<td>0.011</td>
<td>-0.002</td>
<td>(0.003)</td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>Industry share</td>
<td>0.034***</td>
<td>0.068***</td>
<td>0.013</td>
<td>0.066***</td>
<td>-0.025</td>
<td>-0.002</td>
<td>-0.065</td>
<td>-0.002</td>
<td>(0.009)</td>
<td>(0.017)</td>
<td>(0.022)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>Public share</td>
<td>-0.028***</td>
<td>-0.032**</td>
<td>-0.036***</td>
<td>-0.039*</td>
<td>-0.029</td>
<td>-0.014</td>
<td>-0.015</td>
<td>0.029</td>
<td>(0.006)</td>
<td>(0.014)</td>
<td>(0.011)</td>
<td>(0.021)</td>
</tr>
<tr>
<td>N</td>
<td>832</td>
<td>419</td>
<td>764</td>
<td>351</td>
<td>696</td>
<td>283</td>
<td>636</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Clusters</td>
<td>91</td>
<td>91</td>
<td>91</td>
<td>91</td>
<td>91</td>
<td>91</td>
<td>91</td>
<td>91</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standard errors in parentheses
Includes year and country fixed effects.
Clustered s.e.s at NUTS 2 level.
* p < 0.1, ** p < 0.05, *** p < 0.01
Table 3.12: Panel IV - Objective 1 only (NUTS 2 level), 2000-2011
Driscoll-Kraay robust standard errors

<table>
<thead>
<tr>
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<th>Contemporaneous</th>
<th>1st Lead</th>
<th>2nd Lead</th>
<th>3rd Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual expenditures to GDP</td>
<td>2.962***</td>
<td>3.752**</td>
<td>3.408**</td>
<td>3.221***</td>
</tr>
<tr>
<td></td>
<td>(0.535)</td>
<td>(1.441)</td>
<td>(1.312)</td>
<td>(1.067)</td>
</tr>
<tr>
<td>L.GDP Growth</td>
<td>0.023</td>
<td>-0.127***</td>
<td>-0.130**</td>
<td>-0.224</td>
</tr>
<tr>
<td></td>
<td>(0.067)</td>
<td>(0.039)</td>
<td>(0.065)</td>
<td>(0.191)</td>
</tr>
<tr>
<td>Education</td>
<td>0.007***</td>
<td>0.007*</td>
<td>0.005</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.004)</td>
<td>(0.008)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>Industry share</td>
<td>0.023</td>
<td>0.017</td>
<td>-0.007</td>
<td>-0.019</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.033)</td>
<td>(0.033)</td>
<td>(0.034)</td>
</tr>
<tr>
<td>Public share</td>
<td>-0.031**</td>
<td>-0.044*</td>
<td>-0.041**</td>
<td>-0.029</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.022)</td>
<td>(0.019)</td>
<td>(0.021)</td>
</tr>
<tr>
<td>N</td>
<td>817</td>
<td>749</td>
<td>681</td>
<td>621</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
Includes year and country fixed effects.
S.e.s robust to heteroskedasticity, autocorrelation and cross-sectional (spatial) dependence.
*p < 0.1, *p < 0.05, *p < 0.01
CHAPTER 3. FISCAL STIMULUS IN A MONETARY UNION: EVIDENCE FROM EUROZONE REGIONS

Figure 3.1: Annual commitments as a share of GDP by NUTS 2 (representative years, Objectives 1+2)
CHAPTER 3. FISCAL STIMULUS IN A MONETARY UNION: EVIDENCE FROM EUROZONE REGIONS

Figure 3.2: Key explanatory variable and instrumental variable for a representative year
Figure 3.3: GDP Growth vs Trade-weighted Expenditure Spillover Shock: 2001-2011
Chapter 4

Appendices
.1 Appendix for Chapter 1

Conceptual framework in detail

To the best of my knowledge, there is at best a thin literature analyzing the welfare impacts of financial transaction taxes and consequently, their optimality in general (see Subrahmanyam (1998); Dow and Rahi (2000)). Most recently, Dávila (2013) studies the welfare impact of introducing a linear FTT under a model of trading with belief disagreement. Under his baseline model, trading is motivated by either different hedging needs, risk aversion, initial asset holdings (fundamental trading), or beliefs (non-fundamental, suboptimal trading). Assuming there is no redistribution objective and that optimists are mostly buyers and pessimists mostly sellers, Dávila obtains a closed formula for the optimal tax where the reduction in distortion induced by belief disagreement is traded off against the loss in fundamental trading arising from the introduction of the tax. Although a valuable contribution to our theoretical understanding of the welfare implications of an FTT, the formulas for the optimal linear tax presented in that paper are limited in two main fronts from a social welfare perspective: (i) maximizing aggregate welfare involves only the utility of traders, and not that of non-market participants (such as ultimate investors, corporations, savers), and (ii) the only objective of the tax under Dávila’s framework is to serve as a corrective tax for excessive trading caused by divergent beliefs about asset returns - there is no consideration of revenue raising or equity objectives. These are central to much of the recent push for these taxes, and include the need for covering existing VAT loopholes, targeting financial sector rents (Philippon and Reshef (2009); Bierbrauer and Aigner (2015)), increasing income redistribution, and insuring the median taxpayer against large future contingent liabilities arising from the financial system (such as an institutional bailout), for example.

Furthermore, the only two allowed response margins are lock-in (represented by an inactivity region post-tax for those with relatively small benefits of portfolio adjustment) and changes in asset prices. As I discuss in more detail in the following sections, in practice the set of underlying response margins affecting the choice of optimal transaction tax rates resembles Piketty et al. (2014)’s study of optimal top in-

\footnote{Also omitted are the potential double-dividends of such a tax (the use of Pigouvian tax revenues to lower existing distortionary taxes), assuming financial market participants are given a relatively low weight in the social welfare function (which is plausible in multiple European contexts). However, this argument is often called for on the erroneous basis that Pigouvian taxes do not create any deadweight losses of their own; the net effect depends on the social weight of those asymmetrically benefited by other lower taxes relative to the weight of those most directly affected by the FTT.}
come marginal tax rates - a “tale of three elasticities”\textsuperscript{2}. As in Slemrod and Yitzhaki (2002), the first margin of response is “real” substitution away from taxed assets; given the short-run fixed supply of outstanding floating shares, I contend that this kind of response is fully capitalized into asset values, whose change in response to the introduction of FTTs I measure in section 1.3. In addition, there are two major intensive response margins I focus on. There is substantial evidence in support of retiming responses in transaction realizations - first temporarily, by anticipating realizations from immediately after the time of introduction of the tax to immediately before; and second permanently by deferring realizations, thus minimizing the frequency of transaction tax liability (lock-in effect). Finally, there can be tax arbitrage in the form of income shifting across trading platforms and economically equivalent financial instruments.

Slemrod (2001) generalizes a labor-leisure choice under a linear income tax model by allowing individuals to change both their labor supply and avoidance effort in response to tax changes. He shows that the net income and substitution effects of taxes depend both on preferences and the avoidance technology, and econometric analysis cannot usually identify the two forces separately, unless avoidance costs are known. The literature reveals cases of striking avoidance by shifting the timing of capital gains and stock-options realizations (Burman et al. (1994); Goolsbee (2000); Dowd et al. (2012)), suggesting a very low cost of avoidance in the financial sector. Yet, to the best of my knowledge there has been no study to date of income shifting within the sector (in other words, shifting income classification such as through the use of economically equivalent derivatives, as opposed to re-timing of transactions).\textsuperscript{3}

Empirically, absent individual portfolio data on asset holdings and contracts entered into, substitution and different types of avoidance forces have been indistinguishable. This paper fills that gap, by proposing a method of disentangling the weight of each behavioral response using the variation in policy design in the two natural experiments analyzed here.

**Alternative control group difference-in-differences**

The first alternative control group are French and Italian (respectively) publicly listed companies just below the threshold of eligibility (between €500m and €1bn

\textsuperscript{2}“Real” labor supply elasticity can be thought of in the current context as substitution towards untaxed assets, income shifting as equivalent to avoidance through instrument and platform shifting, and bargaining effects comparable to reduction in trading due to retiming.

\textsuperscript{3}In particular, entering into economically equivalent derivative contracts instead of executing true transfers of asset ownership ensures the same payoff to the holding agent while circumventing tax obligations if the former are exempt or subject to lower effective rates.
and between €250m and €500m, respectively). Albeit the prima facie most intuitive control group given the design of the tax giving rise to a natural regression discontinuity, this is possibly the control group of lowest credibility, since growth companies under the threshold may be perceived as potentially included under the tax in future years, which would affect the present value of their returns as well as that of companies already taxed. In addition, at 35 (52 for Italy) total companies (since the treatment groups are those within the interval of eligibility threshold ±€500m and ±€250m, respectively, to mitigate heterogeneity in firm characteristics in the two groups), the around-threshold available sample is extremely small, often lacking statistical power to be informative about any effects\(^4\). Table 4 summarizes the valuation and turnover results for this control group, and Figure 1 provides graphical evidence for the lack of a significant difference in trading patterns between the two groups of stocks around the implementation of the FTT in France.

The second alternative control group consists of American Depositary Receipts for the same shares being affected by the treatment in France and Italy. Each ADR represents a given number/fraction of shares of a foreign company, but are denominated and traded in US$. They trade only in the US, mostly over-the-counter. Mechanically, underlying shares are converted into ADRs by being deposited in a custodian bank and having the corresponding ADRs then issued by a domestic depositary bank. From a firm standpoint, ADRs broaden their potential investor base without having to comply with the reporting requirements of listed companies. From an investor standpoint, these securities enable exposure to the same returns as holding the underlying foreign shares, while avoiding currency exchange and cross-border investment costs. For the purposes of this study, ADRs are considered a tax-exempt control group since they only came under the scope of the tax four months later in France and enforcement is highly questionable as they are traded exclusively outside of Europe. In addition, I include Italian companies with liquid ADRs as a placebo, since in the latter case ADRs were never tax-exempt, so that we should not expect a similar differential effect a priori. By virtue of trading over-the-counter, data on the outstanding number of securities and the unit correspondence between ADRs and the underlying stock is not publicly available, so I use the log of absolute trading volume as my measure of turnover here. I further drop companies whose ADRs have an average daily trading volume of less than 2.5 units; that leaves me with 40/25 companies for the volume estimates in France/Italy\(^5\).

\(^4\)Further research using alternative summary statistics and specifications might be worthwhile conducting to discern any discontinuous effect on the two groups.

\(^5\)Yet another important caveat regarding the usefulness of ADRs for answering the questions at hand is that if ADRs were delisted between the event date and the time of writing of this paper, I may omit the liquidity and price effects on those assets, since I only have access to currently active
While there was an initial decline in valuation of French stocks relative to their respective ADRs on announcement of the tax (February 7th), it was not as large as the decline measured with respect to other comparable assets. The February 27th positive coefficient on domestic ordinary shares is possibly reflective of an arbitrage correction. The most puzzling part is the sharp devaluation of ordinary shares on December 1st, albeit no contemporaneous relative volume change. This could reflect the cancellation of ADRs, which would translate into a dumping of shares into the domestic market, and a reduced supply in the ADR market. Finally, some event dates lose their significance once currency exchange fluctuations are included as a control variable.

While all French high market cap stocks seem to rebound in September towards pre-reform levels similar to the control group, stocks of companies with actively traded ADRs show a second decline in domestic share trading volume a few months after the introduction of the FTT in France (see Figure .2) - not seen in the broader sample. This may be the result of lagged broker adaptation to the discrepancy in treatment between the two securities, or more likely, the larger (albeit lagged) impact of the tax on more liquid shares, since stocks with ADRs tend to be among those with highest turnover in the domestic French equity market. Note that although I replicated the same tests controlling for currency exchange fluctuations, the results presented in Table .5 do not include these controls - hence, the difference in direction between fixed effect coefficients in some of the regressions, which should have a priori been very similar in every column.

The last column in Table .12 further uses as a control group a weighted average of comparable companies (Bloomberg Peers) as the control group. These companies are selected based on comparable industry and financial fundamentals, and are listed in various countries, including the United States, Switzerland, and Germany. I select the weights individually for each company in order to minimize the predictive error of the weighted combination in a pre-treatment period of two years. In that sense, this alternative is similar in form to a synthetic control group.

**Baseline mechanical asset price effect**

Matheson (2011) provides a basic partial equilibrium model of the impact of a proportional transaction tax on asset valuation. This model assumes no behavioral response to the tax and thus provides an upper bound on the valuation effect. Agents are homogeneous, forward-looking and risk neutral and trade every N periods, where
N is determined exogenously by assumption. The tax-inclusive price of a share to the buyer after implementation is then

\[ V(0) = \int_{0}^{N} D_t e^{-rt} dt + (1 - T) e^{-rN} V(N) \]

Iterating forward and assuming constant dividend growth rate \( g \), she gets that

\[ V(0) = \frac{D}{R} \left( \frac{1 - e^{-rN}}{1 - (1 - T) e^{rN}} \right) \cdot (1 - e^{-rN}) \]

where \( r \) is some discount rate, and \( R = r - g > 0 \). Thus the price reduction induced by the tax (the difference between the last expression and \( \frac{D}{R} \)) is an increasing and concave function of \( T \).

For plain equity transactions, the liable party in both case studies is the net buyer, while for derivative contracts in Italy both parties are statutorily liable. Hence, there is an implicit assumption in what follows that the buyer has all the bargaining power in the bidding process, such that there is complete pass-through of the tax to the selling agent at the time of sale. In practice, given forward-looking agents, the price impact of the tax should be fully capitalized at announcement given perfect foresight of the implementation date. While an oversimplistic setup most clearly because of the ad-hoc trading frequency assumption, the Matheson (2011) setup could still provide an upper bound on the price decline we should expect to observe in the data - both due to the behavioral decline of turnover, but also due to the full impact of the tax to current asset holders being discounted by more the greater the anticipation period between announcement and implementation. Given an average holding period for the companies sampled of approximately 2.4 months, the expression above would give us an upper bound in the order of 20% decline in security values due to the tax, which as I show is well above the effective impact by several orders of magnitude, implying either expected reversal of policy, or a sizable behavioral adjustment. As shown in section 1.3, the latter is patent from the data.

**Market breadth**

In addition to being the single most important determinant of the tax base at hand, trading volume can also be informative about the impact of the reform on capital market efficiency, discussed more at length in section 1.1. Transmission of information about the value of underlying assets is one of the key roles of the financial sector as an intermediary between investors and entrepreneurs/firms. One way of thinking about the amount of information available in the market is closely linked to
liquidity – if in expectation, beliefs in the entire economy about the true value of an asset are correct, and individuals have heterogeneous private signals about this value, then a priori, markets with a greater number of participants ought to be more informative about fundamental values. The assumption that the sample of participants is somehow representative of the true distribution of beliefs in the economy is a critical caveat here (if an asset market has a greater ratio of speculators to value investors than the economy-wide distribution, an increase in market participants alone will not translate into increased price informativeness).

Using this rationale, I estimate the analogous relative differential between treatment and control groups for the number of trades executed each day, rather than simply the volume or turnover in the stock. I am using the number of trades as a proxy for the number of participants in the market. Following an increase in transaction costs, the decline in trading volume could be either due to the same people transacting much smaller amounts with the same frequency, or some participants choosing to transact less frequently, but for similar order sizes as before. The intuition behind looking at the response of trades is that in the latter case, the amount of information being aggregated by the price system is reduced. This could imply lower capacity of true price discovery and inefficient resource misallocation.

Indeed, when compared to the estimates in the first part of this section, I find that close to 80% of the decline in stock turnover as a result of the FTT can be attributed to a decline in the number of trades executed (Table .6). Hence, the magnitude of individual portfolio adjustment remains relatively stable, but participation frequency declines sharply. In other words, market breadth declined, while market depth remained unaffected by the increase in participation costs.

A note is due at this point regarding the potential use of exchange-traded funds (ETFs) or other types of investment funds as tax-exempt avoidance opportunities for investors. Since trades executed by these funds would still be reflected in the data used in the estimations above, it is important to understand how such avoidance could affect the results, if at all. While the acquisition of ETF units using a share transfer is considered to be a "contribution" and not a "purchase" of stocks, the fund itself is still liable for the transaction tax as an institutional buyer as it manages its portfolio. Hence, assuming there were a synthetic fund that perfectly replicated the exposure to returns of all shares under the scope of the tax, we should still expect to see an effect of the tax on share prices and turnover, as long as the fund management mirrors the optimal portfolio management of individual investors who before had their cash invested directly in the said stocks. Furthermore, any additional costs incurred by the fund in transacting those shares would most likely be shifted forward to fund contributors (in the form of increased fees for example). Thus, I claim that a decline in observed turnover and asset values cannot be explained by a
shift towards collective investment funds - leaving shifting and deferral responses as the most plausible channels explaining the observed effects. However, this reasoning assumes investors have the same optimal portfolio allocation strategy before and after the tax, as well as before and after shifting to an ETF; if the tax for some reason were to make individual investors more averse towards active portfolio management, for instance, and ETFs were typically less active, then an ETF-oriented shift could produce at least part of the observed decline in trading volumes, and the perceived reduced liquidity would place further downward pressure on prices.

Finally, the analysis of turnover at opening and closing auction times on exchanges in both cases studied in this paper can be useful in testing the hypothesis put forth regarding market composition post-tax: that the counterfactual drop in turnover on exchanges in Italy was compensated by a switch from OTC traders, whereas no such sizable platform shift occurred in France. Closing auctions in particular are more likely to be used by OTC participants shifting platforms, as well as non-HFT traditional regulated exchange participants. As seen from the results shown in Table 4.13, we see a decline in closing auction turnover in France similar to the observed decline in overall lit turnover - driven by non-HFT traders on exchanges -, but no such decline in Italy, reflecting the compensatory effect of OTC participants in those auctions.

Elasticity estimates sensitivity

This section presents confidence intervals for each of the elasticity estimates computed in section 1.3. In addition, I compare the baseline estimates to those under alternative underlying market structure figures, including the share of on-exchange equity trading attributed to high-frequency traders, and the share of OTC versus on-exchange trading. For most point estimates provided, halving pre-existing transaction costs would simply halve the corresponding elasticities.

Recall $\epsilon_{platform}$ was estimated as a range of elasticities, rather than a single point estimate, due to cross-platform shifting attributable to market-making exemptions, empirically not discernible from shifting due to tax incentives. We can impose a confidence interval around this range by using the standard errors of the estimated decline in observed OTC - precisely,

$$\text{Var} (\epsilon_{platform}) = \left( \frac{1}{13.3\%} \right)^2 \cdot \text{Var} (\hat{\beta}_{3\text{OTC,IT}})$$

In turn, the corresponding variance for the anticipation and lock-in response elasticities over-the-counter are given by
\[
\text{Var}\left(\epsilon_{\text{anticipation}}^{\text{OTC}}\right) = \left(\frac{1}{0.26}\right)^2 \cdot \left\{ \text{Var}\left(\hat{\beta}_3^{\text{OTC}\_FR}\right) + \text{Var}\left(\hat{\beta}_3^{\text{Lock-in\_OTC}\_FR}\right) \right\} \\
-2\left(\frac{1}{0.26}\right)^2 \cdot \text{Cov}\left(\hat{\beta}_3^{\text{OTC}\_FR}, \hat{\beta}_3^{\text{Lock-in\_OTC}\_FR}\right)
\]

and

\[
\text{Var}\left(\epsilon_{\text{anticipation}}^{\text{OTC}}\right) = \left(\frac{1}{0.26}\right)^2 \cdot \text{Var}\left(\hat{\beta}_3^{\text{Lock-in\_OTC}\_FR}\right)
\]

The variance for the anticipation elasticity on-exchange is

\[
\text{Var}\left(\epsilon_{\text{anticipation}}^{\text{FTT}}\right) = \left(\frac{1}{0.26}\right)^2 \cdot \left\{ \text{Var}\left(\hat{\beta}_3^{\text{FTT}\_FR}\right) + \text{Var}\left(\hat{\beta}_3^{\text{Lock-in\_FTT}\_FR}\right) \right\} \\
-2\left(\frac{1}{0.26}\right)^2 \cdot \text{Cov}\left(\hat{\beta}_3^{\text{FTT}\_FR}, \hat{\beta}_3^{\text{Lock-in\_FTT}\_FR}\right)
\]

while the lock-in equivalents for each of the key groups of market participants on-exchange are

\[
\text{Var}\left(\epsilon_{\text{Lock-in}}^{\text{OTC}}\right) \approx (-3.125)^2 \cdot \text{Var}\left(\hat{\beta}_3^{\text{5thQuintile\_LIT}\_FR}\right) + (-2.083)^2 \cdot \text{Var}\left(\hat{\beta}_3^{\text{Lock-in\_LIT}\_IT}\right) \\
+ (-0.04167)^2 \cdot \text{Var}\left(\hat{\beta}_3^{\text{OTC}\_IT}\right) - 6.51 \cdot \text{Cov}\left(\hat{\beta}_3^{\text{Lock-in\_LIT}\_IT}, \hat{\beta}_3^{\text{OTC}\_IT}\right) \\
- 0.26 \cdot \text{Cov}\left(\hat{\beta}_3^{\text{Lock-in\_LIT}\_IT}, \hat{\beta}_3^{\text{5thQuintile\_LIT}\_FR}\right) \\
+ 0.09 \cdot \text{Cov}\left(\hat{\beta}_3^{\text{5thQuintile\_LIT}\_FR}, \hat{\beta}_3^{\text{OTC}\_IT}\right)
\]

\[
\text{Var}\left(\epsilon_{\text{Lock-in}}^{\text{FTT}}\right) \approx (48.6)^2 \cdot \text{Var}\left(\hat{\beta}_3^{\text{5thQuintile\_LIT}\_FR}\right) + (-50)^2 \cdot \text{Var}\left(\hat{\beta}_3^{\text{Lock-in\_LIT}\_IT}\right) \\
+ (16.6)^2 \cdot \text{Var}\left(\hat{\beta}_3^{\text{OTC}\_IT}\right) \\
+ 4866.67 \cdot \text{Cov}\left(\hat{\beta}_3^{\text{Lock-in\_LIT}\_IT}, \hat{\beta}_3^{\text{5thQuintile\_LIT}\_FR}\right) \\
- 1622.22 \cdot \text{Cov}\left(\hat{\beta}_3^{\text{5thQuintile\_LIT}\_FR}, \hat{\beta}_3^{\text{OTC}\_IT}\right) \\
- 1666.67 \cdot \text{Cov}\left(\hat{\beta}_3^{\text{Lock-in\_LIT}\_IT}, \hat{\beta}_3^{\text{OTC}\_IT}\right)
\]
Finally, the variance of the elasticity of cash equity trading with respect to a change in transaction taxes on derivatives is given by

$$\text{Var}(\epsilon_{\text{derivative}}) = \left(\frac{5}{2}\right)^2 \cdot \text{Var}(\hat{\beta}^{2\text{nd round},T})$$

Table 7 summarizes these sensitivity bounds. The 3rd and 4th columns correspond to 95% confidence interval bounds. These are wider than the underlying confidence intervals for the relevant parameter estimates due to the affine transformations involved in the calculation of the behavioral elasticities. The last two columns show the same point estimates of elasticities assuming a 60% share of HFT on regulated exchanges instead of 40%, and a pre-tax OTC share of 40% instead of 1/3 in Italy as used in the baseline estimates in section 1.3.

**Capital market efficiency**

**Is stock market volatility detrimental to social welfare?**

By the envelope theorem, the behavioral effect of a tax policy reform on private welfare is approximately zero for a sufficiently small rate change. However, the impact of aggregate behavioral responses on asset returns and realized volatility may have non-trivial effects on social welfare, especially under the presence of externalities - not only among capital market participants, but also on investors, entrepreneurs and savers in the broader economy. One of the foremost arguments put forward in favor of financial transaction taxes is their purported ability to reduce short-term speculative trading activity, perceived as destabilizing for consumer confidence, investment and macroeconomic fluctuations. In fact, Tobin (1978)'s pioneering proposal in favor of transaction taxes itself focused on the goal of reducing market volatility. Not coincidentally, Italy's FTT introduction was part of an legislative package entitled “Stability Law”. Before describing the results of this study with respect to the FTT impact on a variety of volatility measures, it seems critical to ask first whether financial market volatility matters at all empirically as a shock contributing to business cycle fluctuations. There is a relatively thin literature on this subject. Beaudry and Portier (2006) look at the impact of a shock to the first moment of news about future productivity as incorporated in financial market indexes, and estimate it via a vector error correction model using US data, finding that a positive shock increases consumption, investment, output and hours on impact, but not total factor productivity. The literature looking at second moments of financial market indexes’ impact on aggregate variables is of greater interest for the purposes
of this paper, with the most frequently referenced work in that strand being that of Bloom (2009), who simulates the impact of an uncertainty shock on aggregate output, employment and productivity, and finds that uncertainty shocks induce sharp short recessions and recoveries (with a medium-term overshoot). His main measure of stock market uncertainty is the implied volatility index of S&P 100 options with rolling 30-day maturity. Alexopoulos and Cohen (2009) use a similar volatility index to Bloom in addition to a New York Times news based index of uncertainty shocks to estimate their effect on aggregate variables using vector auto-regressions. They report that at a 12 month horizon, uncertainty shocks explain 13% of variance in industrial production, 21% in employment and 18% in productivity.

Bloom (2009) outlines a structural firm-level model with a time-varying second moment of the driving process, as well as non-convex labor and capital adjustment costs, yielding a central region of inaction in hiring and investment. Higher uncertainty (proxied by stock market volatility) expands this region of inaction by making firms more cautious in responding to business conditions. In particular, higher uncertainty increases the real-option value to waiting, inducing firms to scale back their plans. Once uncertainty subsides, activity quickly bounces back as firms address pent-up demand. Parallel arguments can be made for the Eurozone, giving us some observationally grounded motivation for expecting that short-run volatility may be destabilizing for main aggregate variables, justifying at a first pass the use of the FTT as a Pigouvian tax to correct for externalities arising outside the capital markets themselves.

More specifically, by reducing the number of market participants an FTT may lower the informational content of stock prices assuming information about fundamentals is highly dispersed, which in turn causes a rise in the excess volatility of stock returns. The increased volatility makes holding stocks unattractive and induces agents to demand a higher equity risk premium; this is equivalent to a higher expected dividend demanded by capital holders in general equilibrium (a higher expected marginal product of capital). Under standard functional assumptions, the higher required return implies a depressed steady-state level of capital accumulation and output - causing first-order welfare costs by lowering long-run levels of consumption (Hassan and Mertens (2011)). Thus, while the introduction of an FTT per se does not directly reflect increased uncertainty by economic agents about the state of the economy or the future productivity of projects, it can still be a significant source of social welfare-reducing volatility if it decreases the informational efficiency of financial markets.
Do transactions taxes reduce, increase or have no effect on stock market volatility?

Theoretically, it is unclear whether discouraging “disruptive speculation” by increasing the cost of trading would reduce excess volatility in asset prices. Firstly, there is no consensus as to what “excess” volatility is given the difficulty in defining an optimal level thereof. Secondly, while the burden of a transactions tax may fall more heavily on short-term transactions, it is unclear whether these are the ones driving the gaps between market prices and intrinsic values, and furthermore the tax ends up falling on all trading activity, not just speculative trading, thus potentially reducing positive liquidity (this is the core trade-off in Dávila (2013)’s derivation of the optimal linear FTT). This would be the case if market makers were affected by the tax for example.

At a microstructure level, there is a wide theoretical body of work scrutinizing the impact that short-term or speculative transactions have on volatility. One such strand of the literature focuses on heterogeneous agents models (Frankel (1996); Westerhoff (2003))\textsuperscript{6}. These models depart from traditional assumptions of full rationality, with market agents making decisions according to potentially suboptimal “rules of thumb”, and furthermore having different interests, access to funding or capabilities. Lanne and Vesala (2010) argue for instance that a transaction tax is likely to amplify, rather than dampen, volatility in foreign exchange markets stemming from the assumption that informed trader valuations are likely to be less dispersed than those of uninformed traders, and that under a decentralized trading practice a transactions tax penalizes the former more heavily. More recently, Buss et al. (2014) compare the effect of multiple measures on stock-market volatility, and find that only a leverage constraint is effective at curbing it, while a Tobin tax is not.

Empirically, the evidence is still sparse but overwhelmingly in support of either no effect or an increase in volatility following the introduction of a transactions tax. Among other papers, Umlauf (1993), Jones and Seguin (1997), Baltagi et al. (2006) and Pomeranets and Weaver (2011) all find statistically significant increases in volatility\textsuperscript{7} following increases in FTTs. Pomeranets and Weaver (2011), for example, examine nine changes in the level of an FTT levied on equity transactions in New York state between 1932 and 1981 and conclude that an increase in the FTT is related to a statistically significant increase in volatility, bid-ask spreads and price impact on the New York Stock Exchange and the American Stock Exchange. In

\textsuperscript{6}Other branches of the literature focus on zero intelligence atomistic models which reproduce excess volatility through herding behavior in the population of traders (Ehrenstein et al. (2003)), or use game theoretical approaches (Bianconi et al. (2009)).

\textsuperscript{7}Measured as the standard deviation of returns.
turn, Saporta and Kan (1997) are among a couple of other studies that do not find a relationship between FTTs and volatility, but to the best of my knowledge there is a dearth of studies showing a significant decline in volatility being associated with an increase in FTTs (see more recently Becchetti and Ferrari (2013)), thus suggesting that on balance empirical evidence is consistent with arguments made by opponents of the tax.

I further explore the micro data on French and Italian high market cap companies and the respective control groups described above to discern whether there has been any change in the volatility (short-run or long-run) of asset prices. A decline in short-run volatility would be suggestive of a decline in potentially speculative activity. It would likewise be indicative of a smaller price impact of each trade, conditional on the number of trades. Related to the question addressed in the next section, a smaller price impact of individual trades can be associated with greater informativeness of the price system. On the other hand, an increase in volatility is possible if the reduced liquidity induced by lower turnover is sufficiently large to make the market choppier.

In what follows I use three different measures of volatility of firm asset prices: the standard deviation of closing prices (over the month immediately preceding and following the tax reform) for each firm; the daily standard deviation of a firm’s high, low, closing and opening prices; and the average bid-ask spread as a percentage of the daily closing price for the firm. None of these metrics are sufficiently informative across any of the control groups to discern a differential increase or decrease in price volatility for the firms under the scope of the tax.

Standard deviation volatility analysis using volatility of closing daily prices against Dutch/Belgian and Spanish comparable companies is too noisy and not informative (Figures .3 and .4). A similar exercise is equally non-informative for the other two control groups (ADRs and smaller market cap companies)\(^8\). While these results do not necessarily reject the hypothesis that FTTs are volatility-reducing, the modest magnitude of most coefficients do suggest that despite the amount of noise present in the data, the introduction of the taxes had no notable effect on standard volatility measures on-exchange. The second column under each group in Tables .8 and .9 uses the daily standard deviations between high, low, opening and closing prices as its dependent variable.

The third column under each case study uses the daily average bid-ask spread as a percentage of closing price as the left-hand side variable. Due to data limitation reasons, bid-ask spread data is only available since the beginning of 2012 on-exchange and 2013 for OTC, and hence the triple difference-in-differences analysis that has

\(^8\)Results available upon request.
been modified throughout this paper cannot be adequately implemented. Although mostly statistically insignificant, these findings suggest a weak overall impact of the FTT on the volatility of affected stocks. The exception seems to be OTC in Italy, where the bid-ask spread shows a significant decline of 6 basis points as a percentage of share price in March 2013 (the first month of implementation). The much larger turnover effects identified in OTC platforms than on-exchange suggest the reduced market participation may be the principal explanation of the reduced measured volatility, in a way potentially supporting contentions that the tax may have a corrective role - at least wherever reduced turnover cannot be easily circumvented by avoidance. Interestingly, albeit non-statistically significant, these estimates suggest a mirror pattern between OTC and exchange platforms in both countries. In particular, while we observe a slight increase in closing price volatility together with a decline in intraday variation in prices in OTC, the opposite seems to have happened on-exchange. The only significant increase in the measures used occurs on intraday volatility on the Milan stock exchange - which could be accounted for by the explanation used earlier in the paragraph as to why OTC volatility measures may have declined somewhat.

Finally, I include a common measure of the average daily price impact of order flow as proposed by Amihud (2002), a proxy for both illiquidity and realized scaled volatility. For each stock $i$, the measure is defined as:

$$IILLIQ_{i,y} = \frac{1}{D_{iy}} \cdot \sum_{t=1}^{D_{iy}} \frac{|R_{iyt}|}{VOLE_{iyt}}$$

where $|R_{iyt}|$ is the daily absolute return on the stock, $VOLE_{iyt}$ is the respective trading volume in euros, and $D_{iy}$ is the number of days for which data is available for stock $i$ in period $y$ (a year in the standard literature, and a month in this paper). An advantage of this ratio is that it captures transaction costs associated with trading more generally than bid-ask spreads, since part of the return measured in response to trading is price movement to the bid or ask, but also a function of the order depth around the quote. Insofar as price impact is considered by fund managers as lost return associated with a given amount of trading\(^9\), it represents a broader obstacle for costless portfolio reallocation (Lang and Maffett (2011)). Moreover, the Amihud measure enables identification of difference-in-differences effects in the absence of sufficiently long bid-ask spread time series (as is the case for OTC trades). The dependent variable in the fourth column in each case study can be interpreted as the

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\(^9\)The rationale being that price is driven up by the initial purchase and down by the ultimate sale.
price impact cost (as a percentage of original quoted price) of a 1000 Euro trade. As with standard deviation based measures and bid-ask spreads, the analysis is not informative about any significant impact of the introduction of the respective FTTs on market illiquidity proxied by the Amihud measure, on-exchange or OTC.

Consistently across the different metrics, there was a very large relative decline of volatility for both treatment and control groups in the aftermath of August 1st 2012 for France, which can be seen visually from the figure below. Yet, the differential between the two is not sufficiently large to be statistically significant. In contrast, the gap in average intraday volatility between Italian and Spanish high market cap companies seems to narrow slightly around the entry into force of the FTT in March 2013. In order to assess whether alternative measures of stock volatility might suggest a different outcome, Table 10 adds difference-in-differences tests for changes in options-implied volatility and an end-of-day variance ratio for the French case, as well as changes in the volatility of major stock indexes in the treatment and control countries (namely, CAC versus AEX and BEL20).

These results are consistent with experimental evidence reported by Bloomfield et al. (2009), who use a laboratory market to investigate the behavior of uninformed traders in response to a securities transaction tax. While noise trading increases market depth and volume, and reduces bid-ask spreads, it curtails the ability of the market to adjust to new information. Under a transaction tax, both uninformed and informed trader activity gets reduced by approximately the same amount, leaving unaltered the impact of noise trading on the informational efficiency of the market.

Finally, it is worthwhile noting that alternative tax system designs can have important differential effects on market volatility and risk exposure. For example, OTC platforms were taxed more heavily than exchange markets in Italy under the pretext that it would constitute an incentive for market participants to move the bulk of their trading activities to lit markets - which are more transparent and under stricter regulatory conditions than the former. Such a shift in itself, by seemingly improving access to information and mitigating systemic risk exposure potential, may have contributed positively to capital markets efficiency beyond any impact (or lack thereof) on measured volatility as presented above.

A principal role of capital markets as intermediaries is to inform investors about the value of projects (firms, sectors, etc) so as to best reallocate funding resources from those ventures with lowest return potential to the most productive ones. One of the main signals provided for this purpose by capital markets is the correspondence of the price system to the fundamental expected returns associated with an asset. As hinted at by the volatility analysis above, a decline in asset liquidity could be associated with increased participant uncertainty about the fundamental value of the security. In part, this could be reflecting lower informational capacity of the
market, where noise and true signals about fundamental values become more easily confounded. Loss of informativeness in these markets could then have important implications for the efficient intermediation of resource allocation in the economy; this is particularly true in a scenario such as the one of the present case study, as publicly-listed companies in the EU represent over two-thirds of aggregate output. There is also a sizable literature linking idiosyncratic shocks to large market cap firms to a large share of variation in output and productivity over business cycles (Gabaix (2011)). Large firms may also be the most productive in the economy (Melitz and Ottaviano (2005)), exacerbating the welfare loss from misallocation of financial resources. Together with the impact of perceptions of stock market volatility for movements in macroeconomic variables, this is an important area of subsequent research, albeit outside the scope of this paper.
Appendix tables and robustness checks

Table .1: List of treatment and control group firms: France, 2012

<table>
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<tr>
<th>Firm</th>
<th>Sector</th>
<th>Firm</th>
<th>Sector</th>
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<td>Aalberts Industries</td>
<td>Machinery</td>
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Table 2: List of treatment and control group firms: France, 2012 (continued)

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### Table 3: List of treatment and control group firms: Italy, 2013

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</table>

**Notes:**
- **Utilities** includes energy and water supply.
- **Construction Materials** includes construction materials and components.
- **Construction** includes construction services.
- **Commercial Services** includes commercial services.
- **Media** includes media and entertainment.
- **Technology** includes technology and telecommunications.
- **Engineering & Construction** includes engineering and construction services.
- **Biotech & Pharma** includes biotechnology and pharmaceuticals.
- **Banking** includes banking and financial services.
- **Transportation** includes transportation and logistics.
- **Retail** includes retail and consumer goods.
- **Insurance** includes insurance and financial services.
- **Institutional Financial Svcs** includes institutional financial services.
- **Renewable Energy** includes renewable energy and utilities.
- **Medical Equipment & Devices** includes medical equipment and devices.
- **Aerospace & Defense** includes aerospace and defense.
- **Biotech & Pharma** includes biotechnology and pharmaceuticals.
- **Utilities** includes energy and water supply.
- **Construction Materials** includes construction materials and components.
- **Construction** includes construction services.
- **Commercial Services** includes commercial services.
- **Media** includes media and entertainment.
- **Technology** includes technology and telecommunications.
- **Engineering & Construction** includes engineering and construction services.
- **Biotech & Pharma** includes biotechnology and pharmaceuticals.
- **Banking** includes banking and financial services.
- **Transportation** includes transportation and logistics.
- **Retail** includes retail and consumer goods.
- **Insurance** includes insurance and financial services.
- **Institutional Financial Svcs** includes institutional financial services.
- **Renewable Energy** includes renewable energy and utilities.
- **Medical Equipment & Devices** includes medical equipment and devices.
- **Aerospace & Defense** includes aerospace and defense.
- **Biotech & Pharma** includes biotechnology and pharmaceuticals.
### Table 4: Diff-in-Diff French and Italian Small and HMCAP (On-Exchange)

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<td>-0.088</td>
<td>0.002</td>
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<td>(0.503)</td>
<td>(0.002)</td>
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<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
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<td>-0.009**</td>
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<td></td>
<td>(0.004)</td>
<td>(0.004)</td>
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<tr>
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<td>-0.015</td>
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<td>(0.210)</td>
<td>(0.170)</td>
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<td>Month</td>
<td>0.173**</td>
<td>0.291***</td>
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<td>(0.083)</td>
<td>(0.106)</td>
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<td>Month*Year</td>
<td>-0.676***</td>
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<td>(0.117)</td>
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<td>(0.114)</td>
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<td>Year*Treated</td>
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Standard errors in parentheses

Conceptually, the most intuitive test for the treatment effect of the introduction of the equity transactions tax in each country exploits the discontinuity in tax-treatment generated by different company size. Due to the small sample problems raised by such tests, however, these are our weakest set of evidence in support of a large significant effect of the FTT on market values and turnover.

Includes observations six days prior and following the event date.

Standard errors are clustered at the company level.

France counts 35 companies in this sample, 19 of which are in the control group. Italy counts 52 companies in this sample, 27 of which are in the control group.

+ \( p < 0.11 \), ** \( p < 0.05 \), *** \( p < 0.01 \)
Table 4.5: Diff-in-Diff French and Italian HMCAP (Domestic Exchange vs ADRs)

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<td>-0.001</td>
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<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.027)</td>
<td>(0.368)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.548)</td>
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<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.037)</td>
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<td>(0.041)</td>
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<td>(0.173)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Month*Year</td>
<td>-0.534***</td>
<td>-0.397*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.139)</td>
<td>(0.225)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Month*Treated</td>
<td>-0.158*</td>
<td>-0.059</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.089)</td>
<td>(0.171)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year*Treated</td>
<td>-0.275</td>
<td>-0.452*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.174)</td>
<td>(0.254)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Effect - Implementation</td>
<td>-0.156</td>
<td></td>
<td></td>
<td></td>
<td>-0.170</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.144)</td>
<td></td>
<td></td>
<td></td>
<td>(0.234)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-sq</td>
<td>0.002</td>
<td>0.008</td>
<td>0.006</td>
<td>0.010</td>
<td>0.291</td>
<td>0.017</td>
<td>0.057</td>
<td>0.596</td>
</tr>
<tr>
<td>Observations</td>
<td>802</td>
<td>383</td>
<td>683</td>
<td>450</td>
<td>5397</td>
<td>92</td>
<td>154</td>
<td>2621</td>
</tr>
<tr>
<td>Clusters</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>10</td>
<td>10</td>
<td>25</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

Like the treatment discontinuity sample in Table 1, cross-asset estimation of the effect of FTTs is mired by the relatively small sample size. Nonetheless, I identify significant asset value decline of French domestic assets. Italian ADRs are included as a placebo control group in the rightmost three columns.

Includes observations six days prior and following the event date.

Restricted to stock-days for which there is both on-exchange and ADR trading data available.

Standard errors are clustered at the company level.

Samples consist of 40 and 25 companies with active (sponsored and unsponsored) ADRs for France and Italy, respectively.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Table 6: Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), Trades

<table>
<thead>
<tr>
<th></th>
<th>France Turnover Aug 1</th>
<th>France Trades Aug 1</th>
<th>Italy Turnover Mar 1</th>
<th>Italy Trades Mar 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group</td>
<td>0.152</td>
<td>0.025</td>
<td>0.359</td>
<td>0.296</td>
</tr>
<tr>
<td></td>
<td>(0.216)</td>
<td>(0.304)</td>
<td>(0.231)</td>
<td>(0.285)</td>
</tr>
<tr>
<td>Year</td>
<td>-0.030</td>
<td>-0.052</td>
<td>0.076</td>
<td>0.038</td>
</tr>
<tr>
<td></td>
<td>(0.065)</td>
<td>(0.058)</td>
<td>(0.087)</td>
<td>(0.071)</td>
</tr>
<tr>
<td>Month</td>
<td>0.281***</td>
<td>0.219***</td>
<td>0.097**</td>
<td>-0.022</td>
</tr>
<tr>
<td></td>
<td>(0.043)</td>
<td>(0.038)</td>
<td>(0.043)</td>
<td>(0.043)</td>
</tr>
<tr>
<td>Month*Year</td>
<td>-0.471***</td>
<td>-0.382***</td>
<td>-0.129**</td>
<td>-0.037</td>
</tr>
<tr>
<td></td>
<td>(0.057)</td>
<td>(0.053)</td>
<td>(0.058)</td>
<td>(0.047)</td>
</tr>
<tr>
<td>Month*Treated</td>
<td>-0.083</td>
<td>-0.102**</td>
<td>-0.009</td>
<td>0.102*</td>
</tr>
<tr>
<td></td>
<td>(0.055)</td>
<td>(0.044)</td>
<td>(0.069)</td>
<td>(0.060)</td>
</tr>
<tr>
<td>Year*Treated</td>
<td>-0.022</td>
<td>-0.037</td>
<td>-0.012</td>
<td>-0.040</td>
</tr>
<tr>
<td></td>
<td>(0.085)</td>
<td>(0.069)</td>
<td>(0.115)</td>
<td>(0.092)</td>
</tr>
<tr>
<td>Treatment Effect - Implementation</td>
<td>-0.279***</td>
<td>-0.232***</td>
<td>0.010</td>
<td>-0.095</td>
</tr>
<tr>
<td></td>
<td>(0.071)</td>
<td>(0.062)</td>
<td>(0.083)</td>
<td>(0.069)</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.032</td>
<td>0.016</td>
<td>0.018</td>
<td>0.010</td>
</tr>
<tr>
<td>Observations</td>
<td>11513</td>
<td>11342</td>
<td>8325</td>
<td>8017</td>
</tr>
<tr>
<td>Clusters</td>
<td>165</td>
<td>161</td>
<td>125</td>
<td>124</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

This table supports the claim that the bulk of the post-FTT reduction in trading volume was driven by a smaller number of trades executed daily, rather than smaller transaction sizes.

Includes observations one month prior and following the event date.

Standard errors are clustered at the company level.

* p < 0.1, ** p < 0.05, *** p < 0.01


### Table 7: Sensitivity of Behavioral Elasticity Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Lower C.I. Bound</th>
<th>Upper C.I. Bound</th>
<th>60% HFT share</th>
<th>50% OTC share</th>
</tr>
</thead>
<tbody>
<tr>
<td>ϵ_{anticipation}</td>
<td>−0.975</td>
<td>−1.504</td>
<td>−0.446</td>
<td>−0.975</td>
<td>−0.975</td>
</tr>
<tr>
<td>ϵ_{OTC lock-in}</td>
<td>0</td>
<td>−0.152</td>
<td>0.114</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ϵ_{platform}</td>
<td>[−3.375, −6.375]</td>
<td>[−4.453, −7.453]</td>
<td>[−2.297, −5.297]</td>
<td>[−3.375, −6.375]</td>
<td>[−3.375, −6.375]</td>
</tr>
<tr>
<td>ϵ_{TTT lock-in}</td>
<td>−0.225</td>
<td>−0.415</td>
<td>−0.035</td>
<td>−0.225</td>
<td>−0.225</td>
</tr>
<tr>
<td>ϵ_{HFT lock-in}</td>
<td>−0.8125</td>
<td>−1.117</td>
<td>−0.508</td>
<td>−1.219</td>
<td>−0.222</td>
</tr>
<tr>
<td>ϵ_{derivative}</td>
<td>−9</td>
<td>−15.148</td>
<td>−2.852</td>
<td>−6</td>
<td>−13.722</td>
</tr>
<tr>
<td></td>
<td>−0.465</td>
<td>−0.651</td>
<td>−0.279</td>
<td>−0.465</td>
<td>−0.465</td>
</tr>
</tbody>
</table>
Table 8: Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), Volatility Effect On-Exchange

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Last Price S.D.</td>
<td>Intraday Price S.D.</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>-0.127 (0.868)</td>
<td>0.495** (0.149)</td>
</tr>
<tr>
<td>Year</td>
<td>-0.097 (0.193)</td>
<td>-0.070 (0.044)</td>
</tr>
<tr>
<td>Month</td>
<td>0.439** (0.174)</td>
<td>0.583*** (0.031)</td>
</tr>
<tr>
<td>Month*Year</td>
<td>-0.929*** (0.321)</td>
<td>-0.740*** (0.041)</td>
</tr>
<tr>
<td>Month*Treated</td>
<td>-0.127 (0.228)</td>
<td>-0.093** (0.044)</td>
</tr>
<tr>
<td>Year*Treated</td>
<td>1.635 (1.659)</td>
<td>-0.032 (0.056)</td>
</tr>
<tr>
<td>Treatment Effect (Interaction)</td>
<td>-0.244 (0.497)</td>
<td>0.046 (0.052)</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.004 (1.11)</td>
<td>0.001 (7530)</td>
</tr>
<tr>
<td>Observations</td>
<td>696 (15232)</td>
<td>7530 (14111)</td>
</tr>
<tr>
<td>Clusters</td>
<td>177 (177)</td>
<td>170 (170)</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
This table presents evidence of little or no net effect of the transactions tax on standard measures of stock market volatility. The results presented cannot reject the hypothesis that the actual impact may have been heterogeneous across more low-latency (and arguably efficiency-relevant) measures of volatility. The standard deviation of closing prices, intraday prices, and the average bid-ask spread are intended to capture aggregate price dispersion. In addition, the Amihud liquidity measure is meant to capture realized scaled volatility.
Includes observations one month prior and following the event date (enactment of the tax).

Standard errors are clustered at the company level.

* p < 0.1, ** p < 0.05, *** p < 0.01
Table .9: Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), Volatility Effect OTC

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Italy</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Last Price S.D.</td>
<td>Intraday Price S.D.</td>
<td>Bid ask spread</td>
<td>Amihud</td>
<td>Last Price S.D.</td>
<td>Intraday Price S.D.</td>
<td>Bid ask spread</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>-0.051</td>
<td>0.437**</td>
<td>0.015</td>
<td>-0.001</td>
<td>-0.183**</td>
<td>-0.706***</td>
<td>-1.286***</td>
</tr>
<tr>
<td></td>
<td>(0.590)</td>
<td>(0.154)</td>
<td>(0.021)</td>
<td>(0.001)</td>
<td>(0.086)</td>
<td>(0.184)</td>
<td>(0.075)</td>
</tr>
<tr>
<td>Year</td>
<td>-0.080</td>
<td>-0.076</td>
<td>-0.001</td>
<td>0.121</td>
<td>-0.058</td>
<td>0.102**</td>
<td>0.059**</td>
</tr>
<tr>
<td></td>
<td>(0.139)</td>
<td>(0.052)</td>
<td>(0.001)</td>
<td>(0.117)</td>
<td>(0.088)</td>
<td>(0.048)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>Month</td>
<td>1.163</td>
<td>0.533***</td>
<td>0.009</td>
<td>-0.001</td>
<td>0.095</td>
<td>0.059**</td>
<td>-0.002</td>
</tr>
<tr>
<td></td>
<td>(0.717)</td>
<td>(0.041)</td>
<td>(0.016)</td>
<td>(0.001)</td>
<td>(0.070)</td>
<td>(0.048)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>Month*Year</td>
<td>-1.548**</td>
<td>-0.809***</td>
<td>0.001</td>
<td>0.121</td>
<td>-0.078</td>
<td>-0.139*</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>(0.751)</td>
<td>(0.053)</td>
<td>(0.001)</td>
<td>(0.058)</td>
<td>(0.082)</td>
<td>(0.048)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Month*Treated</td>
<td>-0.959</td>
<td>-0.054</td>
<td>0.016</td>
<td>0.004</td>
<td>-0.062</td>
<td>-0.080</td>
<td>-0.059**</td>
</tr>
<tr>
<td></td>
<td>(0.721)</td>
<td>(0.048)</td>
<td>(0.017)</td>
<td>(0.002)</td>
<td>(0.072)</td>
<td>(0.062)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>Year*Treated</td>
<td>0.045</td>
<td>0.009</td>
<td>0.003**</td>
<td>-0.098</td>
<td>0.055</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.178)</td>
<td>(0.066)</td>
<td>(0.002)</td>
<td>(0.019)</td>
<td>(0.017)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Effect (Interaction)</td>
<td>0.800</td>
<td>-0.041</td>
<td>-0.006*</td>
<td>0.049</td>
<td>-0.061</td>
<td>-0.009</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.762)</td>
<td>(0.062)</td>
<td>(0.003)</td>
<td>(0.071)</td>
<td>(0.125)</td>
<td>(0.008)</td>
<td></td>
</tr>
</tbody>
</table>

R-sq 0.020 0.108 0.007 0.001 0.034 0.080 0.720 0.002
Observations 656 11256 5244 11323 569 7151 1694 6474
Clusters 168 169 149 165 147 147 73 125

Standard errors in parentheses

This table reproduces the tests for volatility change for over-the-counter prices. While still not able to reject clearly the lack of an effect on aggregate volatility measures, I find some evidence that OTC volatility may have declined somewhat relative to pre-reform levels.

Includes observations one month prior and following the event date.

Standard errors are clustered at the company level.

*p < 0.1, **p < 0.05, ***p < 0.01
Table 10: Diff-in-Diff French HMCAP (vs Dutch), Volatility Robustness

<table>
<thead>
<tr>
<th></th>
<th>Implied Volatility</th>
<th>Variance ratio</th>
<th>Autocorrelation</th>
<th>Index volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group</td>
<td>0.118*</td>
<td>0.025</td>
<td>0.027</td>
<td>1.276***</td>
</tr>
<tr>
<td></td>
<td>(0.068)</td>
<td>(0.088)</td>
<td>(0.040)</td>
<td>(0.430)</td>
</tr>
<tr>
<td>Month</td>
<td>-0.075***</td>
<td>0.197***</td>
<td>-0.086*</td>
<td>14.011***</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.072)</td>
<td>(0.043)</td>
<td>(0.964)</td>
</tr>
<tr>
<td>Month*Treated</td>
<td>0.005</td>
<td>0.039</td>
<td>-0.007</td>
<td>0.605</td>
</tr>
<tr>
<td></td>
<td>(0.022)</td>
<td>(0.106)</td>
<td>(0.052)</td>
<td>(1.408)</td>
</tr>
<tr>
<td>Year</td>
<td>-0.028</td>
<td>0.009</td>
<td>0.517</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.072)</td>
<td>(0.042)</td>
<td>(0.649)</td>
<td></td>
</tr>
<tr>
<td>Month*Year</td>
<td>-0.161</td>
<td>-0.102*</td>
<td>-11.581***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.108)</td>
<td>(0.054)</td>
<td>(1.138)</td>
<td></td>
</tr>
<tr>
<td>Year*Treated</td>
<td>-0.068</td>
<td>0.006</td>
<td>3.238***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.096)</td>
<td>(0.053)</td>
<td>(0.858)</td>
<td></td>
</tr>
<tr>
<td>Treatment Effect (Interaction)</td>
<td>0.236</td>
<td>0.013</td>
<td>-0.334</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.235)</td>
<td>(0.069)</td>
<td>(1.658)</td>
<td></td>
</tr>
<tr>
<td>R-sq</td>
<td>0.035</td>
<td>0.019</td>
<td>0.090</td>
<td>0.850</td>
</tr>
<tr>
<td>Observations</td>
<td>4716</td>
<td>652</td>
<td>11466</td>
<td>142</td>
</tr>
<tr>
<td>Clusters</td>
<td>131</td>
<td>165</td>
<td>162</td>
<td></td>
</tr>
</tbody>
</table>

Standard errors in parentheses

Implied volatility (IVOL_MONEYNESS in Bloomberg) is computed as the end of day volatility obtained by equating the Black-Scholes formula to the European option price, for an option with 90 days maturity and 100% moneyness. The dependent variable in column 2 is the ratio between the variance of the daily maximum intraday return (between highest and lowest prices) and that of the daily closing price return. Column 3 estimates the treatment effect on daily return autocorrelation. The indexes whose volatility is the dependent variable for the last column are CAC, AEX and BEL20.

Includes observations one month prior and following the event date (enactment of the tax).

Standard errors are clustered at the company level in columns 1-3, and heteroskedasticity robust in column 4.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
### Table 11: Diff-in-Diff French HMCAP (vs Dutch), Prices Robustness

<table>
<thead>
<tr>
<th></th>
<th>2012 Baseline</th>
<th>2006 Placebo</th>
<th>Alternative Benchmarks</th>
<th>2012 at implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fama-French</td>
<td>SBF250</td>
<td>FTSEurofirst 300</td>
<td></td>
</tr>
<tr>
<td>Treatment Group</td>
<td>0.001</td>
<td>0.000</td>
<td>0.003</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.002)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Announcement date</td>
<td>0.008***</td>
<td>-0.003</td>
<td>0.008***</td>
<td>0.015***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.002)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Treatment Effect - Announcement</td>
<td>-0.012***</td>
<td>0.004</td>
<td>-0.016***</td>
<td>-0.016***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.010</td>
<td>0.040</td>
<td>0.016</td>
<td>0.020</td>
</tr>
<tr>
<td>Observations</td>
<td>860</td>
<td>860</td>
<td>612</td>
<td>860</td>
</tr>
<tr>
<td>Clusters</td>
<td>172</td>
<td>172</td>
<td>153</td>
<td>172</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

The first column corresponds to the baseline difference-in-differences effect identified in the paper. The second column augments the baseline specification to incorporate the Fama-French SMB and HML factors. The third column in this table shows a placebo difference-in-differences test in 2005-2006. The fourth and fifth columns estimate the effect of the FTT announcement on asset prices using alternative market benchmarks to compute abnormal returns. The last column tests any changes in prices around the implementation, rather than announcement date of the FTT. Includes observations six months prior and following the announcement date, with an event window of 5 days around the latter.

Standard errors are clustered at the company level.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

### Table 12: Diff-in-Diff French HMCAP (vs Dutch), Turnover Robustness

<table>
<thead>
<tr>
<th></th>
<th>Baseline Turnover Aug 1</th>
<th>2006 Placebo Turnover Aug 1</th>
<th>Foreign Exchanges Turnover Aug 1 London</th>
<th>Turnover Aug 1 Frankfurt</th>
<th>Peer Group Turnover Aug 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group</td>
<td>0.152</td>
<td>0.471*</td>
<td>-0.333</td>
<td>-0.176</td>
<td>-0.160</td>
</tr>
<tr>
<td></td>
<td>(0.216)</td>
<td>(0.268)</td>
<td>(0.245)</td>
<td>(0.247)</td>
<td>(0.109)</td>
</tr>
<tr>
<td>Year</td>
<td>-0.030</td>
<td>0.031</td>
<td>-0.097</td>
<td>-0.134</td>
<td>-0.095*</td>
</tr>
<tr>
<td></td>
<td>(0.065)</td>
<td>(0.136)</td>
<td>(0.244)</td>
<td>(0.174)</td>
<td>(0.049)</td>
</tr>
<tr>
<td>Month</td>
<td>0.281***</td>
<td>-0.007</td>
<td>-0.213</td>
<td>0.149</td>
<td>0.081***</td>
</tr>
<tr>
<td></td>
<td>(0.043)</td>
<td>(0.064)</td>
<td>(0.166)</td>
<td>(0.097)</td>
<td>(0.027)</td>
</tr>
<tr>
<td>Month*Year</td>
<td>-0.471***</td>
<td>0.048</td>
<td>0.113</td>
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<td>0.212***</td>
</tr>
<tr>
<td></td>
<td>(0.057)</td>
<td>(0.078)</td>
<td>(0.279)</td>
<td>(0.158)</td>
<td>(0.030)</td>
</tr>
<tr>
<td>Month*Treated</td>
<td>-0.083</td>
<td>-0.325***</td>
<td>-0.027</td>
<td>0.362***</td>
<td>0.114***</td>
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<tr>
<td></td>
<td>(0.055)</td>
<td>(0.092)</td>
<td>(0.189)</td>
<td>(0.122)</td>
<td>(0.038)</td>
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<tr>
<td>Year*Treated</td>
<td>-0.022</td>
<td>-0.041</td>
<td>0.830***</td>
<td>0.522**</td>
<td>0.032</td>
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<tr>
<td></td>
<td>(0.085)</td>
<td>(0.155)</td>
<td>(0.268)</td>
<td>(0.202)</td>
<td>(0.051)</td>
</tr>
<tr>
<td>Treatment Effect - Implementation</td>
<td>-0.279***</td>
<td>-0.130</td>
<td>-1.178***</td>
<td>-0.723***</td>
<td>-0.532***</td>
</tr>
<tr>
<td></td>
<td>(0.071)</td>
<td>(0.168)</td>
<td>(0.313)</td>
<td>(0.184)</td>
<td>(0.049)</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.042</td>
<td>0.014</td>
<td>0.042</td>
<td>0.012</td>
<td>0.035</td>
</tr>
<tr>
<td>Observations</td>
<td>11513</td>
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<td>5083</td>
<td>4937</td>
<td>13686</td>
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<tr>
<td>Clusters</td>
<td>165</td>
<td>146</td>
<td>137</td>
<td>136</td>
<td>103</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

The first column corresponds to the baseline difference-in-differences effect identified in the paper. The second column shows a placebo difference-in-differences test in 2005-2006. The third and fourth columns show no evidence of an increase in relative trading of taxed assets on foreign exchanges, suggesting there was no significant geographic revision in the aftermath of the implementation of the FTT in France. The last column uses a weighted average of comparable companies (Bloomberg Peers) as the control group.

Includes observations one month prior and following the event date.

Standard errors are clustered at the company level.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
### Table 13: Diff-in-Diff French and Italian HMCAP (vs Dutch & Spanish), Opening and Closing Auction Turnover

<table>
<thead>
<tr>
<th></th>
<th>France Opening Auction</th>
<th>France Closing Auction</th>
<th>Both Opening Auction</th>
<th>Holland Opening Auction</th>
<th>Both Closing Auction</th>
<th>Both</th>
</tr>
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<td>Treatment Group</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.005</td>
<td>0.277</td>
<td>0.220</td>
<td>-0.722**</td>
<td>-0.732**</td>
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<tr>
<td></td>
<td>(0.276)</td>
<td>(0.295)</td>
<td>(0.266)</td>
<td>(0.201)</td>
<td>(0.213)</td>
<td>(0.190)</td>
</tr>
<tr>
<td>Year</td>
<td>-0.077</td>
<td>-0.010</td>
<td>-0.008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.083)</td>
<td>(0.055)</td>
<td>(0.061)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.430***</td>
<td>0.128***</td>
<td>0.197***</td>
<td>0.065**</td>
<td>0.066**</td>
<td>0.075**</td>
</tr>
<tr>
<td></td>
<td>(0.055)</td>
<td>(0.049)</td>
<td>(0.035)</td>
<td>(0.031)</td>
<td>(0.031)</td>
<td>(0.029)</td>
</tr>
<tr>
<td>Month*Year</td>
<td>-0.617***</td>
<td>-0.275***</td>
<td>-0.337***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.088)</td>
<td>(0.059)</td>
<td>(0.057)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Month*Treated</td>
<td>-0.200***</td>
<td>0.028</td>
<td>-0.047</td>
<td>0.034</td>
<td>0.023</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>(0.065)</td>
<td>(0.056)</td>
<td>(0.044)</td>
<td>(0.053)</td>
<td>(0.039)</td>
<td>(0.037)</td>
</tr>
<tr>
<td>Year*Treated</td>
<td>-0.106</td>
<td>0.064</td>
<td>0.047</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.098)</td>
<td>(0.069)</td>
<td>(0.072)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Effect</td>
<td>-0.070</td>
<td>-0.311***</td>
<td>-0.245***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implementation</td>
<td>(0.099)</td>
<td>(0.067)</td>
<td>(0.067)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-sq</td>
<td>0.032</td>
<td>0.016</td>
<td>0.018</td>
<td>0.041</td>
<td>0.057</td>
<td>0.073</td>
</tr>
<tr>
<td>Observations</td>
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<td>10559</td>
<td>10326</td>
<td>13822</td>
<td>14169</td>
<td>13775</td>
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<tr>
<td>Clusters</td>
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<td>155</td>
<td>155</td>
<td>122</td>
<td>122</td>
<td>122</td>
</tr>
</tbody>
</table>

Standard errors in parentheses.

Estimates for Italy represent difference-in-differences for the treatment year only, due to data availability.

Includes observations one month prior and following the event date.

Standard errors are clustered at the company level.

*p < 0.1, ** p < 0.05, *** p < 0.01
Table .14: Italian Option Volume

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Italy</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Option Volume Aug 1</td>
<td>Option Volume Jun 1</td>
<td>Option Volume Sep 1</td>
</tr>
<tr>
<td>Treatment Group</td>
<td>-4.172***</td>
<td>-0.268</td>
<td>-0.798</td>
</tr>
<tr>
<td></td>
<td>(0.819)</td>
<td>(0.558)</td>
<td>(0.511)</td>
</tr>
<tr>
<td>Year</td>
<td>-0.324</td>
<td>0.193</td>
<td>-0.500</td>
</tr>
<tr>
<td></td>
<td>(0.281)</td>
<td>(0.238)</td>
<td>(0.312)</td>
</tr>
<tr>
<td>Month</td>
<td>0.492***</td>
<td>0.258</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>(0.119)</td>
<td>(0.170)</td>
<td>(0.265)</td>
</tr>
<tr>
<td>Month*Year</td>
<td>-0.406**</td>
<td>-0.320</td>
<td>0.396</td>
</tr>
<tr>
<td></td>
<td>(0.167)</td>
<td>(0.236)</td>
<td>(0.311)</td>
</tr>
<tr>
<td>Month*Treated</td>
<td>-0.453***</td>
<td>-0.428**</td>
<td>0.427</td>
</tr>
<tr>
<td></td>
<td>(0.156)</td>
<td>(0.193)</td>
<td>(0.282)</td>
</tr>
<tr>
<td>Year*Treated</td>
<td>0.270</td>
<td>0.572</td>
<td>0.835**</td>
</tr>
<tr>
<td></td>
<td>(0.312)</td>
<td>(0.347)</td>
<td>(0.352)</td>
</tr>
<tr>
<td>Treatment Effect</td>
<td>-0.079</td>
<td>-0.156</td>
<td>-0.542</td>
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<tr>
<td></td>
<td>(0.222)</td>
<td>(0.341)</td>
<td>(0.341)</td>
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<tr>
<td>R-sq</td>
<td>0.231</td>
<td>0.017</td>
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<tr>
<td>Observations</td>
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<td>3414</td>
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<tr>
<td>Clusters</td>
<td>97</td>
<td>78</td>
<td>76</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

This table presents difference-in-differences estimates of changes in exchange-traded options volume at the time of announcement of the postponement of the derivatives tax in Italy (Jun 1st, 2013) and at the time of implementation of the derivatives tax (Sep 1st, 2013). The treatment and control groups are the same as in the baseline estimation, constrained only by data availability on exchange-traded options. The dependent variable is the ln of the ratio of option volume to each company’s equity float.

Includes observations one month prior and following the event date.

Standard errors are clustered at the company level.

* p < 0.1, ** p < 0.05, *** p < 0.01
Appendix figures

Figure 1: France: Small vs HMCAP trading volume, 2012

Figure 2: France: ADR vs domestic treatment group trading volume, 2012
Figure 3: France: Intraday Price Volatility (s.d., on exchange)

Figure 4: Italy: Intraday Price Volatility (s.d., on exchange)
Figure 5: France: Undifferenced Log Turnover for Treatment and Control Groups (treatment year)

Figure 6: Italy: Undifferenced Log Turnover for Treatment and Control Groups (treatment year)
Figure .7: France: Bloomberg peers vs high market cap French turnover

Figure .8: France: Undifferenced Log Turnover for Treatment and Alternative Control Group (treatment year)
Figure 9: Temporary anticipation vs permanent lock-in effect (illustration)
Figure .10: Italy: High market cap Spanish vs Italian turnover, second-half of 2013 (treatment year)

Figure .11: Web search intensity for CFD-provider IG Italia around news of a derivative tax postponement
.2 Appendix for Chapter 2

Equilibrium with transaction taxes and a single market

Portfolio allocation demand (Lemma 1)

In period 2 (\(\equiv T-1\)) the investor solves the problem

\[
V^* [W_{3i}; 2] \equiv \max_{X_{2i}, Y_{2i}} \left[ \mathbb{E}_2 [C_{3i}] - \frac{A}{2} \text{Var} [C_{3i}] \right]
\]

Using a second period budget constraint of

\[
Y_{2i} = Z_{2i} + [D + (1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2] X_{1i} + Y_{1i} (1 + r) - (1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2 X_{2i} + T_{2i},
\]

a third period budget constraint of

\[
C_{3i} = Z_{3i} + (1 + D) X_{2i} + (1 + r) Y_{2i}
\]

and substituting into (1) above, we get

\[
V^* [W_{3i}; 2] \equiv \max_{X_{2i}, Y_{2i}} \mathbb{E}_2 [Z_{3i} + (1 + D) X_{2i}]
\]

\[
+ \left[ (1 + r) \cdot \{Z_{2i} + [D + (1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2] X_{1i} + Y_{1i} (1 + r) - (1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2 X_{2i} + T_{2i} \} \right]
\]

\[
- \frac{A}{2} \text{Var} [Z_{3i} + (1 + D) X_{2i}]
\]

\[
- \frac{A}{2} \text{Var} [(1 + r) \cdot \{Z_{2i} + [D + (1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2] X_{1i} + Y_{1i} (1 + r) - (1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2 X_{2i} + T_{2i} \}]
\]

Replacing \(r = 1\), taking \(X_{1i}\) and prices as given, and expanding the variance terms, the first-order condition with respect to \(X_{2i}\) is:

\[
\mathbb{E}_2 (1 + D) - 2 \cdot (1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2 - AX_{2i} \text{Var} [D] - A \text{Cov}_i (Z_{3i}, D) = 0
\]

\[
\Rightarrow \frac{-2 (1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2 + \mathbb{E}_2 (1 + D) - A \text{Cov}_i (Z_{3i}, D)}{A \text{Var} [D]} = X_{2i}^*
\]

where \(\text{sgn} \Delta X_{ti} = +(-)\) if \(X_{ti} - X_{t-1,i} > (<)0\).

Moving back to period 1, the investor solves
\[ V^*[W_{3i}; 1] = \max_{X_{1i}, Y_{1i}} \left[ \mathbb{E}_t [C_{3i}] - \frac{A}{2} \text{Var} [C_{3i}] \right] \tag{2} \]

Using the first period budget constraint of
\[ Y_{1i} = (1 + \tau \cdot \text{sgn} \Delta X_{1i}) P_1 X_0 - (1 + \tau \cdot \text{sgn} \Delta X_{1i}) P_1 X_{1i} + T_{1i} \]
and substituting into (2) (as well as \( X_{2i}^* \) and \( Y_{2i}^* \)), we have
\[
V^*[W_{3i}; 1] = \max_{X_{1i}, Y_{1i}} \mathbb{E}_t [Z_{3i} + (1 + D) X_{2i}^* + (1 + r) Y_{2i}^*] \\
- \frac{A}{2} \text{Var} [Z_{3i} + (1 + D) X_{2i}^* + (1 + r) Y_{2i}^*] \\
= \max_{X_{1i}, Y_{1i}} \mathbb{E}_t \left[ (1 + D) - \frac{2(1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2 + \mathbb{E}_2(1 + D) - ACov_t(Z_{3i}, D)}{\text{Var}[D]} \right] \\
+ \mathbb{E}_2 \left[ [(D + (1 + \tau \cdot \text{sgn} \Delta X_{2i})) P_2] X_{1i} + 2 \cdot [(1 + \tau \cdot \text{sgn} \Delta X_{1i}) P_1 X_0 - (1 + \tau \cdot \text{sgn} \Delta X_{1i}) P_1 X_{1i} + T_{1i}] \right] \\
- \mathbb{E}_t \left\{ (1 + \tau \cdot \text{sgn} \Delta X_{3i}) P_2 \left[ -\frac{2(1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2 + \mathbb{E}_2(1 + D) - ACov_t(Z_{3i}, D)}{\text{Var}[D]} \right] + T_{2i} \right\} \\
- A \left( -\frac{2(1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2 + \mathbb{E}_2(1 + D) - ACov_t(Z_{3i}, D)}{\text{Var}[D]} \right)^2 \text{Var}(D) \\
- A \left( -\frac{2(1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2 + \mathbb{E}_2(1 + D) - ACov_t(Z_{3i}, D)}{\text{Var}[D]} \right) \text{Cov}_t(Z_{3i}, D) \\
- 2AX_{1i}^2 \text{Var}(D) - 4AX_{1i} \text{Cov}_t(Z_{2i}, D) \]
which gives us the first-order condition with respect to \( X_{1i}^* \):
\[-2(1 + \tau \cdot \text{sgn} \Delta X_{1i}) P_1 + 2\mathbb{E}_t [D + (1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2] - 4AX_{1i} \text{Var}[D] - 4ACov_t[Z_{2i}, D] = 0 \]
\[-(1 + \tau \cdot \text{sgn} \Delta X_{1i}) P_1 + \mathbb{E}_t [D + (1 + \tau \cdot \text{sgn} \Delta X_{2i}) P_2] - 2ACov_t[Z_{2i}, D] = X_{1i}^* \]

**Prices**

In period 2, taking \( P_1 \) and \( X_{1i} \) as given, and using the allocations derived in section 2.2, \( P_2 \) solves the market clearing condition:
In turn in period 1, $P_1$ solves
\[
\begin{align*}
\int_{i \in \text{buyers}} (X_{i}^* - X_0)dF(i) = & \quad \int_{i \in \text{sellers}} (X_{i}^* - X_0)dF(i) \\
- \int_{i \in \text{buyers}} \frac{-(1+\tau)P_1 + E_{1i}[D + (1+\tau \cdot \sgn \Delta X_{2i})P_2] - 2A\text{Cov}_i[Z_{2i},D]}{2AVar[D]} - X_0dF(i) = & \quad \int_{i \in \text{sellers}} \frac{-(1-\tau)P_1 + E_{1i}[D + (1+\tau \cdot \sgn \Delta X_{2i})P_2] - 2A\text{Cov}_i[Z_{2i},D]}{2AVar[D]} - X_0dF(i) \\
\Rightarrow \int_{i \in \mathcal{T}} \frac{\bar{D} + (1+\tau \cdot \sgn \Delta X_{2i})P_2 - 2A\text{Cov}_i[Z_{2i},D] - X_0 \cdot 2AVar[D]}{(1+\tau \cdot \sgn \Delta X_{1i})} dF(i) = & \quad P_1
\end{align*}
\]

Substituting for \(E_{1i}[P_2] = P_2\), we get

\[
\begin{align*}
\int_{i \in \mathcal{T}} \frac{\bar{D} + (1+\tau \cdot \sgn \Delta X_{2i})P_2 - 2A\text{Cov}_i[Z_{2i},D] - X_0 \cdot 2AVar[D]}{(1+\tau \cdot \sgn \Delta X_{1i})} dF(i) = & \quad P_1 \\
\Rightarrow \int_{i \in \mathcal{T}} \frac{\bar{D} + (1+\tau \cdot \sgn \Delta X_{2i})P_2 - 2A\text{Cov}_i[Z_{2i},D] - X_0 \cdot 2AVar[D]}{(1+\tau \cdot \sgn \Delta X_{1i})} dF(i) = & \quad \frac{4}{5} P_1 \\
\int_{i \in \mathcal{T}} \frac{1 + 3\bar{D} - 4A\text{Cov}_i[Z_{2i},D] - A\text{Cov}_i[Z_{3i},D] - X_0 \cdot 5AVar[D]}{2(1+\tau \cdot \sgn \Delta X_{1i})} dF(i) = & \quad P_1
\end{align*}
\]

Finally, plugging this expression back into \(P_2\), we have

\[
\begin{align*}
\int_{i \in \mathcal{T}} \frac{2 + \bar{D} + (1+\tau \cdot \sgn \Delta X_{2i})}{5(1+\tau \cdot \sgn \Delta X_{1i})} \left\{ \int_{i \in \mathcal{T}} \frac{1 + 3\bar{D} - 4A\text{Cov}_i[Z_{2i},D] - A\text{Cov}_i[Z_{3i},D] - X_0 \cdot 5AVar[D]}{2(1+\tau \cdot \sgn \Delta X_{1i})} dF(i) \right\} + 2A\{\text{Cov}_i[Z_{2i},D] - \text{Cov}_i[Z_{3i},D]\} dF(i) = & \quad P_2 \\
\Rightarrow \int_{i \in \mathcal{T}} \frac{1 + \bar{D} - 2A\text{Cov}_i[Z_{3i},D] - X_0 \cdot AVar[D]}{2(1+\tau \cdot \sgn \Delta X_{1i})} dF(i) = & \quad P_2
\end{align*}
\]
Derivation of Proposition 1

In period 1, note that for any given set of period 2 taxes (τ₂), trader i is a net buyer in that period iff

\[-(1 + τ₁ \cdot sgnΔX₁i) P₁ + E₁ [D + (1 + τ₂ \cdot sgnΔX₂i) P₂] - 2ACovᵢ[Z₂ᵢ, D] > X₀ \]

\[\Rightarrow \] \[-(1 + τ₁) P₁ + E₁ [D + (1 + τ₂ \cdot sgnΔX₂i) P₂] - 2ACovᵢ[Z₂ᵢ, D] > X₀ \]

and a net seller iff

\[-(1 + τ₁ \cdot sgnΔX₁i) P₁ + E₁ [D + (1 + τ₂ \cdot sgnΔX₂i) P₂] - 2ACovᵢ[Z₂ᵢ, D] < X₀ \]

\[-(1 - τ₁) P₁ + E₁ [D + (1 + τ₂ \cdot sgnΔX₂i) P₂] - 2ACovᵢ[Z₂ᵢ, D] < X₀ \]

Equivalently, there is an inaction region defined by

\[-(1 - τ₁) P₁ + ζ₁ > X₀ > -(1 + τ₁) P₁ + ζ₁ \]

where ζ₁ = E₁ [D + (1 + τ₂ \cdot sgnΔX₂i) P₂] - 2ACovᵢ[Z₂ᵢ, D], and v₁ = 2Var[D].

The inaction region in period 2 can be defined through a similar reasoning to the one for period 1. We know that in period 2 a trader i is a net buyer iff

\[-2 (1 + τ₂) P₂ + E₂ (1 + D) - ACovᵢ(Z₃ᵢ, D) > X₁ᵢ \]

and a net seller iff

\[-2 (1 - τ₂) P₂ + E₂ (1 + D) - ACovᵢ(Z₃ᵢ, D) < X₁ᵢ \]

So the inaction region is defined by

\[-2 (1 - τ₂) P₂ + ζ₂ > X₁ᵢ > -2 (1 + τ₂) P₂ + ζ₂ \]

where ζ₂ = E₂ (1 + D) - ACovᵢ(Z₃ᵢ, D) and v₂ = Var[D].
Social planner problem under a Pigouvian correction motive

In this subsection, investors disagree about expected returns (the first moment in the distribution of returns) of the risky asset, as in Dávila (2013). Concretely, this means \( E_i[D] \neq E_j[D], \ i \neq j \). The social planner chooses a Pigouvian tax rate in effect in the second period (in what follows, \( \tau \equiv \tau_2 \)), and we set \( \tau_1 = 0 \). The planner is paternalistic (in that she does not respect the subjective beliefs of individual investors, which may be different from her own, when calculating social welfare), and does not hold any informational advantage over market participants. Social welfare \( V \) is expressed as the sum of the indirect utility for every investor, under the distribution of returns used by the planner

\[
V(\tau) = \int \lambda_i V_i dF(i)
\]

where \( \lambda_i > 0 \) is the welfare weight corresponding to each investor and

\[
V_i \equiv \mathbb{E}[U_i(W_{3i})] = -e^{-\hat{V}_i} \quad \text{with} \quad \hat{V}_i \equiv \mathbb{E}[W_{3i}(X_{1i},X_{2i},P_1,P_2)] - \frac{A}{2} \text{Var}[W_{3i}(X_{1i},X_{2i},P_1,P_2)]
\]

\( \hat{V}_i \) is thus the individual certainty equivalent from the planner’s perspective. Substituting \( W_{3i} \) explicitly, and using the fact that the planner does take into account the rebate of tax receipts to traders, we can re-express \( \hat{V}_i \) as

\[
\hat{V}_i = \mathbb{E}[Z_{3i} + (1+D)X_{2i} + 2 \cdot \{Z_{2i} + [D+(1+\tau \cdot \text{sgn} \Delta X_{2i})]P_2]X_{1i]}
+ 2Y_{1i} - (1+\tau \cdot \text{sgn} \Delta X_{2i})P_2X_{2i} \cdot P_{2i}]]
\]

\[
- \frac{A}{2} \text{Var} [Z_{3i} + (1+D)X_{2i} + 2 \cdot \{Z_{2i} + [D+(1+\tau \cdot \text{sgn} \Delta X_{2i})]P_2]X_{1i]
+ 2Y_{1i} - (1+\tau \cdot \text{sgn} \Delta X_{2i})P_2X_{2i} \cdot P_{2i}]]
\]

\[
= \mathbb{E}[(1+D)X_{2i} + 2 \cdot \{[D+P_2]X_{1i} + 2 \cdot \{P_1X_0 - P_1X_{1i} - P_2X_{2i}\}
\]

\[
- \frac{A}{2} \{ (X_{2i}^2 + 4X_{1i}^2) \text{Var}(D) + 2X_{2i} \text{Cov}(Z_{3i},D) + 8X_{1i} \text{Cov}(Z_{2i},D) \}
\]

where \( X_{2i} \) and \( X_{1i} \) are chosen optimally by traders in each period as derived above.

The marginal effect of a tax change on the indirect utility of individual investors \( \frac{dV_i}{d\tau} \) equals

\[
\frac{dV_i}{d\tau} = Ae^{-\hat{V}_i} \frac{d\hat{V}_i}{d\tau} = \mathbb{E} \left[ U_i'(W_{3i}) \right] \frac{d\hat{V}_i}{d\tau}
\]

\( ^{10} \)So \( T_{1i} = 0 \).
In turn, the marginal change in the certainty equivalent can be expressed as

\[
\frac{d\hat{V}_i}{d\tau} = \left[ \mathbb{E} \left[ 1 + D - 2P_2 \right] - AX_{2i} \text{Var} (D) - A \text{Cov}_i (Z_{3i}, D) \right] \frac{dX_{2i}}{d\tau}
\]

\[
+ \left[ 2 \mathbb{E} \left[ D + P_2 - 2P_1 \right] - 4AX_{1i} \text{Var} (D) - 4A \text{Cov}_i (Z_{2i}, D) \right] \frac{dX_{1i}}{d\tau}
\]

\[
- 2\Delta X_{2i} \frac{dP_2}{d\tau} - 4\Delta X_{1i} \frac{dP_1}{d\tau}
\]

\[
= \left[ \left\{ \mathbb{E} [D] - \mathbb{E}_{2i} (D) \right\} + 2(\tau \cdot \text{sgn} \Delta X_{2i}) P_2 \right] \frac{dX_{2i}}{d\tau}
\]

\[
+ \left[ 2 \left\{ \mathbb{E} [D] - \mathbb{E}_{1i} (D) \right\} - 2P_1 - 2 \cdot (\tau \cdot \text{sgn} \Delta X_{2i}) P_2 \right] \frac{dX_{1i}}{d\tau}
\]

\[
- 2\Delta X_{2i} \frac{dP_2}{d\tau} - 4\Delta X_{1i} \frac{dP_1}{d\tau}
\]

Thus the marginal change in social welfare from the introduction of a financial transaction tax in the second trading period is

\[
\frac{dV}{d\tau} = \int \lambda_i \mathbb{E} \left[ U'_i (W_{3i}) \right] \left[ \left\{ \mathbb{E} [D] - \mathbb{E}_i (D) \right\} \frac{dX_{2i}}{d\tau} + 2 \left\{ \mathbb{E} [D] - \mathbb{E}_i (D) \right\} \frac{dX_{1i}}{d\tau} \right] dF(i)
\]

\[
+ \int \lambda_i \mathbb{E} \left[ U'_i (W_{3i}) \right] \left[ 2(\tau \cdot \text{sgn} \Delta X_{2i}) P_2 \frac{dX_{2i}}{d\tau} - \{2(\tau \cdot \text{sgn} \Delta X_{2i}) P_2 + 2P_1 \} \frac{dX_{1i}}{d\tau} \right] dF(i)
\]

\[
- 2\Delta X_{2i} \frac{dP_2}{d\tau} - 4\Delta X_{1i} \frac{dP_1}{d\tau}
\]

The tax affects social welfare by simultaneously reducing externality-generating trades (driven by cross-sectional variation of expectations of asset returns), fundamental trades (driven by different risk-aversion, initial endowments, or hedging needs), and intertemporal terms-of-trade. Assuming (as in Dávila (2013)) i) no redistribution \( \Rightarrow \lambda_i \mathbb{E} \left[ U'_i (W_{3i}) \right] \) constant, \( \forall i \), and using market clearing\(^{11}\), expression

\(^{11}\int \Delta X_{ti} dF (i) = 0 \) and \( \int \frac{dX_{ti}}{d\tau} dF (i) = 0 \).
(7) becomes:

\[
\frac{dV}{d\tau} = \int \left[ -\mathbb{E}_i(D) \frac{dX_{2i}}{d\tau} - 2\mathbb{E}_i(D) \frac{dX_{1i}}{d\tau} + 2(\tau \cdot \text{sgn} \Delta X_{2i}) P_2 \left( \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right) \right] dF(i)
\]

Further assuming ii) that optimists (those with high $\mathbb{E}_i(D)$) are buyers ($\mathcal{B}$) and pessimists are sellers ($\mathcal{S}$)\(^{12}\), the above is simplified locally around $\tau = 0$ to

\[
\frac{dV}{d\tau} = \int \left[ -\mathbb{E}_i(D) \frac{dX_{2i}}{d\tau} \big|_{\tau=0} - 2\mathbb{E}_i(D) \frac{dX_{1i}}{d\tau} \big|_{\tau=0} \right] dF(i)
\]

We know that $\frac{dX_{2i}}{d\tau} < (>) 0$ for $i \in \mathcal{B}(\mathcal{S})$, $\frac{dX_{1i}}{d\tau} > (<? 0$ for $i \in \mathcal{B}(\mathcal{S})$, and trading volume in the second period declines ($\int_{i \in \mathcal{B}} \frac{dX_{2i}}{d\tau} dF(i) < 0$) and the opposite happens to volume in the first period ($\int_{i \in \mathcal{B}} \frac{dX_{1i}}{d\tau} dF(i) > 0$). Therefore

\[
\frac{dV}{d\tau} = -\int \mathbb{E}_i(D) \frac{dX_{2i}}{d\tau} \big|_{\tau=0} dF(i) - \int \mathbb{E}_i(D) \frac{dX_{1i}}{d\tau} \big|_{\tau=0} dF(i)
\]

Albeit intertemporal portfolio allocation decisions being distorted, the current setting mirrors the welfare analysis of a static portfolio selection model in that there is an unambiguous first-order gain from reducing trades driven by belief disagreement, and only a second order loss from the reduction in fundamental trading.

The optimal Pigouvian tax rate $\tau^*$ is

\[
\tau^* = \text{argmax}_\tau V(\tau)
\]

which in the general case is given by

\[^{12}\text{Formally, this assumption implies the cross-sectional covariance of expected payoffs with respect to marginal changes in equilibrium allocations in each period locally around $\tau = 0$ is negative. For more details, please see section 3 in Dávila (2013).} \]
as it is the same across investors), we are left with a zero optimal tax

rather than a general result of CARA preferences.

Equilibrium with dividend taxes instead of transaction taxes

This section is meant to highlight the source of the independence of current prices from future taxes under an FTT seen in section 2.2. In particular, this independence does not carry over to an equilibrium with dividend taxes, suggesting that this property is due to the nature of the tax and the distribution of idiosyncratic shocks, rather than a general result of CARA preferences.

The revised budget constraints are:

\[ C_{3i} = Z_{3i} + (1 + D (1 - \tau_3)) X_{2i} + (1 + r) Y_{2i} + T_{3i} \]

\[ Y_{2i} = Z_{2i} + [D (1 - \tau_2) + P_2] X_{1i} + Y_{1i} (1 + r) - P_2 X_{2i} + T_{2i} \]

\[=\int_{\lambda_i \mathbb{E} \left[ U_i' (W_{a3}) \right]} \left[ \mathbb{E} [D] - \mathbb{E} (D) \right] \frac{dX_{2i}}{d\tau} + 2 \left( \mathbb{E} [D] - \mathbb{E} (D) \right) \frac{dX_{1i}}{d\tau} \right] dF (i) + \int_{\lambda_i \mathbb{E} \left[ U_i' (W_{a3}) \right]} \left[ -2\Delta X_{2i} \frac{dP_2}{d\tau} - 4\Delta X_{1i} \frac{dP_1}{d\tau} + 2 (\tau - sgn \Delta X_{2i}) P_2 \frac{dX_{2i}}{d\tau} - (2 (\tau - sgn \Delta X_{2i}) P_2 + 2 P_1) \frac{dX_{1i}}{d\tau} \right] dF (i)

\Rightarrow \tau^* = -\frac{\int_{\lambda_i \mathbb{E} \left[ U_i' (W_{a3}) \right]} \left[ \mathbb{E} [D] - \mathbb{E} (D) \right] \frac{dX_{2i}}{d\tau} + 2 \left( \mathbb{E} [D] - \mathbb{E} (D) \right) \frac{dX_{1i}}{d\tau} \right] dF (i)}{\int_{\lambda_i \mathbb{E} \left[ U_i' (W_{a3}) \right]} \left[ sgn \Delta X_{2i} P_2 \left( \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right) \right] dF (i)}

\Rightarrow \tau^* = -\frac{\int_{\lambda_i \mathbb{E} \left[ U_i' (W_{a3}) \right]} \left[ \mathbb{E} [D] - \mathbb{E} (D) \right] \frac{dX_{2i}}{d\tau} + 2 \left( \mathbb{E} [D] - \mathbb{E} (D) \right) \frac{dX_{1i}}{d\tau} \right] dF (i)}{\int_{\lambda_i \mathbb{E} \left[ U_i' (W_{a3}) \right]} \left[ sgn \Delta X_{2i} P_2 \left( \frac{dX_{2i}}{d\tau} - \frac{dX_{1i}}{d\tau} \right) \right] dF (i)}

Because of assumption (ii), in order for the tax to be positive, the denominator above has to be negative. Furthermore, if we cancel the Pigouvian motive by setting \( \mathbb{E}_i (D) = \mathbb{E} (D) \) (whether or not the expectation is correct does not matter, as long as it is the same across investors), we are left with a zero optimal tax\(^\text{13}\).

Equilibrium with dividend taxes instead of transaction taxes

\(\text{13}\)Since \( \mathbb{E} (D) \) is a constant, and \( \int_{\tau \in \mathbb{T}} \frac{dX_{2i}}{d\tau} dF (i) = 0 \).
\[ Y_{1i} = P_1 X_0 - P_1 X_{1i} \]

In period 2, the investor solves the problem:

\[ V^* [W_{3i}; 2] \equiv \max_{X_{2i}, Y_{2i}} \left[ E_{2i} [C_{3i}] - \frac{A}{2} \text{Var} [C_{3i}] \right] \]

Substituting in period 2 and 3 budget constraints, we get

\[
\begin{align*}
V^* [W_{3i}; 2] &\equiv \max_{X_{2i}, Y_{2i}} E_{2i} [Z_{3i} + (1 + D (1 - \tau_3)) X_{2i}] \\
&+ 2 \cdot (Z_{2i} + [D (1 - \tau_2) + P_2] X_{1i} + Y_{1i} (1 + r) - P_2 X_{2i} + T_{2i}) + T_{3i}] \\
&- \frac{A}{2} \text{Var} [Z_{3i} + (1 + D (1 - \tau_3)) X_{2i}] \\
&+ 2 \cdot (Z_{2i} + [D (1 - \tau_2) + P_2] X_{1i} + Y_{1i} (1 + r) - P_2 X_{2i} + T_{2i}) + T_{3i}\end{align*}
\]

The FOC with respect to \(X_{2i}\) is

\[
\begin{align*}
E_{2i}[1+D(1-\tau_3)]-2P_2-A(1-\tau_3)^2\text{Var}(D)X_{2i}-A(1-\tau_3)\cdot\text{Cov}_i(Z_{3i},D) &= 0 \\
\frac{1+(1-\tau_3)\cdot E_{2i}[D]-2P_2-A(1-\tau_3)\cdot\text{Cov}_i(Z_{3i},D)}{A(1-\tau_3)^2\text{Var}(D)} &= X^*_{2i}
\end{align*}
\]

In the first period, the investor solves:

\[ V^*[W_{3i}; 1] \equiv \max_{X_{1i}, Y_{1i}} \left[ E_{1i} [C_{3i}] - \frac{A}{2} \text{Var} [C_{3i}] \right] \]

Substituting for the first period budget constraint and \(X^*_{2i}\) and \(Y^*_{2i}\), we get

\[
\begin{align*}
V^*[W_{3i}; 1] &\equiv \max_{X_{1i}, Y_{1i}} E_{1i} \left[ (1+D(1-\tau)) \cdot \frac{1+(1-\tau)\cdot E_{2i}[D]-2P_2-A\text{Cov}_i(Z_{3i},D)}{A(1-\tau)^2\text{Var}(D)} \right] \\
&+ E_{1i} \left[ 2 \cdot \left( \frac{1+(1-\tau)\cdot E_{2i}[D]-2P_2-A\text{Cov}_i(Z_{3i},D)}{A(1-\tau)^2\text{Var}(D)} + T_{2i} \right) + T_{3i} \right] \\
&- \frac{A}{2} \left\{ (1-\tau)^2 \left( \frac{1+(1-\tau)\cdot E_{2i}[D]-2P_2-A\text{Cov}_i(Z_{3i},D)}{A(1-\tau)^2\text{Var}(D)} \right)^2 \text{Var}(D) \right\} \\
&- \frac{A}{2} \left\{ 2(1-\tau) \cdot \frac{1+(1-\tau)\cdot E_{2i}[D]-2P_2-A\text{Cov}_i(Z_{3i},D)}{A(1-\tau)^2\text{Var}(D)} \text{Cov}_i(Z_{3i},D) \right\} \\
&- 2AX_{1i}^2(1-\tau)^2\text{Var}(D) - 4AX_{1i}(1-\tau)\text{Cov}_i(Z_{2i},D)
\end{align*}
\]
FOC w.r.t. $X_{1i}$:

$$-2P_1 + 2\mathbb{E}_{1i}[D(1-\tau_2) + P_2] - 4AX_{1i}(1-\tau_2)^2\text{Var}(D) - 4A(1-\tau_2)\text{Cov}_i(Z_{2i}, D) = 0$$

$$-P_1 + \mathbb{E}_{1i}[D(1-\tau_2) + P_2] - 2A(1-\tau_2)\text{Cov}_i(Z_{2i}, D) = 2A(1-\tau_2)^2\text{Var}(D)$$

Using the same assumptions as with the transaction tax, in period 2, $P_2$ solves

$$\int_{i \in \text{buyers}} (X_{2i}^* - X_{1i}^*)dF(i) =$$

$$\int_{i \in \text{sellers}} (X_{2i}^* - X_{1i}^*)dF(i) \Rightarrow$$

$$\int_{i \in \mathbb{T}} \frac{1 + (1-\tau_3) \cdot \mathbb{E}_{2i}[D] - 2P_2 - A(1-\tau_3) \cdot \text{Cov}_i(Z_{3i}, D)}{A(1-\tau_3)^2\text{Var}(D)}$$

$$-\frac{-P_1 + \mathbb{E}_{1i}[D(1-\tau_2) + P_2] - 2A(1-\tau_2)\text{Cov}_i(Z_{2i}, D)}{2A(1-\tau_2)^2\text{Var}(D)}dF(i) = 0$$

$$\int_{i \in \mathbb{T}} \frac{2(1-\tau_2)^2 \cdot \mathbb{E}_{2i}[D] - A(1-\tau_3) \cdot \text{Cov}_i(Z_{3i}, D)}{2A(1-\tau_2)^3(1-\tau_3)^2\text{Var}(D)}$$

$$-\frac{(1-\tau_3)^2 \cdot \mathbb{E}_{1i}[D(1-\tau_2)] - 2A(1-\tau_2)\text{Cov}_i(Z_{2i}, D)}{2A(1-\tau_2)^3(1-\tau_3)^2\text{Var}(D)}$$

$$-\frac{[2(1-\tau_2)^2 + (1-\tau_3)^2] P_2}{2A(1-\tau_2)^3(1-\tau_3)^2\text{Var}(D)} dF(i) = 0$$

$$\Rightarrow \int_{i \in \mathbb{T}} \frac{2(1-\tau_2)^2 + 2\{(1-\tau_3)(1-\tau_2)(\tau_3 - 2\tau_2 + 1)\} \cdot \mathbb{D}}{[2(1-\tau_2)^2 + (1-\tau_3)^2]} dF(i)$$

$$+ \int_{i \in \mathbb{T}} \frac{(1-\tau_3)^2 \{ P_1 + 2A(1-\tau_2)\text{Cov}_i(Z_{2i}, D) \} - 2A(1-\tau_2)^2(1-\tau_3)\text{Cov}_i(Z_{3i}, D)}{[2(1-\tau_2)^2 + (1-\tau_3)^2]} dF(i) = P_2$$

(7)

In turn, $P_1$ is given by
\[
\int_{i \in \text{buyers}} (X_{li}^* - X_0) dF(i) = \\
- \int_{i \in \text{sellers}} (X_{li}^* - X_0) dF(i) \Rightarrow \\
\int_{i \in T} \left( -P_1 + E_{i1} \left[ D(1-\tau_2) + P_2 - 2A(1-\tau_2) Cov_i(Z_{2i}, D) \right] - X_0 \right) dF(i) = 0 \\
\Rightarrow \int_{i \in T} \left( -P_1 + E_{i1} \left[ D(1-\tau_2) + P_2 - 2A(1-\tau_2) Cov_i(Z_{2i}, D) - X_0 \left( 2A(1-\tau_2)^2 Var(D) \right) \right] - X_0 \right) dF(i) = 0 \\
\Rightarrow \int_{i \in T} \left( D(1-\tau_2) + P_2 - 2A(1-\tau_2) Cov_i(Z_{2i}, D) - X_0 \left( 2A(1-\tau_2)^2 Var(D) \right) \right) dF(i) = P_1 
\] (8)

Plugging this expression back into \( P_2 \), we get
\[
\int_{i \in T} \frac{2(1-\tau_2)^2 + 2\{1-(1-\tau_2)\cdot(\tau_3 - 2\tau_2 + 1)\}}{[2(1-\tau_2)^2 + (1-\tau_3)^2]} \cdot \overline{D} \, dF(i)
\]

\[
+ \int_{i \in T} \frac{(1-\tau_3)^2 \{ P_1 + 2A(1-\tau_2)Cov_i(Z_{2i}, D) \} - 2A(1-\tau_2)^2(1-\tau_3)Cov_i(Z_{3i}, D)}{[2(1-\tau_2)^2 + (1-\tau_3)^2]} \, dF(i) = P_2
\]

\[
\Rightarrow \int_{i \in T} \frac{2(1-\tau_2)^2 + 2\{1-(1-\tau_2)\cdot(\tau_3 - 2\tau_2 + 1)\}}{[2(1-\tau_2)^2 + (1-\tau_3)^2]} \cdot \overline{D} \, dF(i)
\]

\[
+ \int_{i \in T} \frac{(1-\tau_3)^2 \{ P_1 + 2A(1-\tau_2)Cov_i(Z_{2i}, D) \} - 2A(1-\tau_2)^2(1-\tau_3)Cov_i(Z_{3i}, D)}{[2(1-\tau_2)^2 + (1-\tau_3)^2]} \, dF(i) = P_2
\]

\[
\Rightarrow \int_{i \in T} \frac{2(1-\tau_2)^2 + 2\{1-(1-\tau_2)\cdot(\tau_3 - 2\tau_2 + 1) + (1-\tau_3)^2 \cdot (1-\tau_2)\}}{[2(1-\tau_2)^2 + (1-\tau_3)^2]} \cdot \overline{D} \, dF(i)
\]

\[
- \int_{i \in T} \frac{(1-\tau_3)^2 \{ X_0(2A(1-\tau_2)^2\text{Var}(D)) \}}{[2(1-\tau_2)^2 + (1-\tau_3)^2]} \, dF(i)
\]

\[
+ \int_{i \in T} \frac{-2A(1-\tau_2)^2(1-\tau_3)Cov_i(Z_{3i}, D)}{[2(1-\tau_2)^2 + (1-\tau_3)^2]} \, dF(i) = \frac{2(1-\tau_2)^2 P_2}{[2(1-\tau_2)^2 + (1-\tau_3)^2]}
\]

\[
\Rightarrow \int_{i \in T} 1 + (1-\tau_3) \cdot \overline{D} - (1-\tau_3)^2 \{ X_0(A\text{Var}(D)) \} - A(1-\tau_3)Cov_i(Z_{3i}, D) \, dF(i) = P_2 \quad (9)
\]

And finally plugging (9) back into \( P_1 \), we obtain
In this setup, $P_1$ depends directly on both future dividend taxes (see equation (10)), but $P_2$ only depends directly on $\tau_3$ (equation (9)). $\tau_3$ reduces the after-tax return of risky asset holdings in period 3, irrespective of whether those units were held as original endowment, purchased in period 1 or purchased in period 2; thus, demand for the risky asset declines in both trading periods, which implies that both $P_1$ and $P_2$ depend negatively on $\tau_3$. In contrast, $\tau_2$ works as a capital levy from the perspective of period 2 traders - how much of the asset they buy or sell in period 2 does not affect their tax burden, only their trading choices in period 1, which therefore push $P_1$ downwards, leaving $P_2$ unchanged.

In the transaction tax context (in particular, refer to equations (2.3) and (2.4)), we see that in each period $\tau_t$ affects $P_t$ through the investor’s intratemporal decision to reallocate its portfolio holdings towards the riskless asset. In addition, as with the dividend tax $\tau_D^{14}$ above, there is a distortion of the intertemporal margin which is exactly offset by a change in $P_s$ (where $s \neq t$). This stems from the fact that since both transaction counterparties are equally liable for the tax and the distribution of endowment shocks is symmetric, market clearing requires that in the case of an increase in $\tau_2$, the set of active buyers shifting from period 2 to period 1 (putting upward pressure on $P_1$, ceteris paribus) be matched by an equivalent set of sellers shifting in the same direction (putting downward pressure on $P_1$). To see this, note that holding $X_0$ and $A$ fixed, at the margin traders shifting intertemporally must have mirror hedging needs in periods 2 and 3. The same type of symmetric intertemporal substitution effect cancels out, and each price is only affected by the intratemporal substitution induced by a change in the contemporaneous transaction tax.

\[ \int_{i \in T} \overline{D}(1-\tau_2) + P_2 - 2A(1-\tau_2)\text{Cov}_i(Z_{2i}, D) - X_0(2A(1-\tau_2)^2 \text{Var}(D))dF(i) = P_1 \]

\[ \Rightarrow \int_{i \in T} \overline{D}(1-\tau_2) + \left\{ \int_{i \in T} 1 + (1-\tau_3) - (1-\tau_3)^2 \{ X_0(A \text{Var}(D)) \} dF(i) - 2A(1-\tau_2)^2 \text{Var}(D)dF(i) \right\} dF(i) = P_1 \]

14 For clarity of discussion, I now refer to dividend taxes with a superscript $\tau_D^t$. 
CHAPTER 4. APPENDIXES

OTC

Equilibrium with two markets

In period 3, conditional on the actions chosen in periods 1 and 2, the budget constraint facing investors is:

\[ C_{3i} = Z_{3i} + (1 + D) X_{2i} + (1 + r) Y_{2i} \]

In period 2, the two possible budget constraints available to investors are:

\[ Y_{2i} = Z_{2i} + \left[ D + (1 + \tau_{\text{EX},2} \cdot \text{sgn} \Delta X_{2i}) P_2 \right] X_{1i} + Y_{1i} (1 + r) - (1 + \tau_{\text{EX},2} \cdot \text{sgn} \Delta X_{2i}) P_2 X_{2i} + T_{2i} \]

if on-exchange

\[ Y_{2i} = Z_{2i} + \left[ D + (1 + \tau_{\text{OTC},2} \cdot \text{sgn} \Delta X_{2i}) (1 - \mu \cdot \text{sgn} \Delta X_{2i}) P_2 \right] X_{1i} + Y_{1i} (1 + r) - (1 + \tau_{\text{OTC},2} \cdot \text{sgn} \Delta X_{2i}) (1 - \mu \cdot \text{sgn} \Delta X_{2i}) P_2 X_{2i} + T_{2i} - \gamma \]

if OTC

Finally, in period 1 investors face

\[ Y_{1i} = [(1 + \tau_{\text{EX},1} \cdot \text{sgn} \Delta X_{1i}) P_1] X_0 - (1 + \tau_{\text{EX},1} \cdot \text{sgn} \Delta X_{1i}) P_1 X_{1i} + T_{1i} \]

if on-exchange

\[ Y_{1i} = [(1 + \tau_{\text{OTC},1} \cdot \text{sgn} \Delta X_{1i})(1 - \mu \cdot \text{sgn} \Delta X_{1i}) P_1] X_0 - (1 + \tau_{\text{OTC},1} \cdot \text{sgn} \Delta X_{1i})(1 - \mu \cdot \text{sgn} \Delta X_{1i}) P_1 X_{1i} + T_{1i} - \gamma \]

if OTC

As before, we can express the corresponding derived utility of wealth as

\[ V^* [W_{3i}; t] \equiv \max_{X_{ti}, Y_{ti}} \left[ \mathbb{E}_{ti} [C_{3i}] - \frac{A}{2} \text{Var} [C_{3i}] \right] \] for \( t = 1, 2 \)

\[ V^* [W_{3i}; 3] \equiv C_{3i} - \frac{A}{2} \text{Var} [C_{3i}] \]

Then in period 2 the investor solves the problem

\[ V^* [W_{3i}; 2] \equiv \max_{X_{2i}, Y_{2i}} \left[ \mathbb{E}_{2i} [C_{3i}] - \frac{A}{2} \text{Var} [C_{3i}] \right] \] (11)

Combining the second and third period budget constraints for on-exchange and OTC trading, respectively, we get
\[
C_3 = Z_{3i} + (1+D)X_{2i} + 2\{Z_{2i} + [D+(1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2]X_{1i} + 2Y_{1i}\}
+ 2\{-(1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2X_{2i}+T_{2i}\} \quad \text{if on-exchange}
\]
\[
C_3 = Z_{3i} + (1+D)X_{2i} + 2\{Z_{2i} + [D+(1+\tau_{OTC,2}\cdot sgn \Delta X_{2i})(1-\mu\cdot sgn \Delta X_{2i})P_2]X_{1i} + 2Y_{1i}\}
+ 2\{-(1+\tau_{OTC,2}\cdot sgn \Delta X_{2i})(1-\mu\cdot sgn \Delta X_{2i})P_2X_{2i}+T_{2i}-\gamma\} \quad \text{if OTC}
\]

and substituting into (11), we get

\[
V^*[W_{3i};2] \equiv V^*_{OTC}[W_{3i};2] + (1-\mathbb{1})V^*_E[X_{3i};2]
\]

\[
V^*_E[X_{3i};2] \equiv \max_{X_{2i},Y_{2i}} \mathbb{E}_2\{Z_{3i} + (1+D)X_{2i}\}
+ \mathbb{E}_2\{2\cdot\{Z_{2i} + [D+(1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2]X_{1i} + 2Y_{1i}\}
- (1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2X_{2i}+T_{2i}\}\}
- \frac{A}{2}\Var[Z_{3i} + (1+D)X_{2i}]
- \frac{A}{2}\Var[2\cdot\{Z_{2i} + [D+(1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2]X_{1i} + 2Y_{1i}\}
- (1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2X_{2i}+T_{2i}\}\}
\]

\[
V^*_{OTC}[W_{3i};2] \equiv \max_{X_{2i},Y_{2i}} \mathbb{E}_2\{Z_{3i} + (1+D)X_{2i}\}
+ \mathbb{E}_2\{2\cdot\{Z_{2i} + [D+(1+\tau_{OTC,2}\cdot sgn \Delta X_{2i})(1-\mu\cdot sgn \Delta X_{2i})P_2]X_{1i} + 2Y_{1i}\}
+ 2\{-(1+\tau_{OTC,2}\cdot sgn \Delta X_{2i})(1-\mu\cdot sgn \Delta X_{2i})P_2X_{2i}+T_{2i}-\gamma\}\}
- \frac{A}{2}\Var[Z_{3i} + (1+D)X_{2i}]
- \frac{A}{2}\Var[2\cdot\{Z_{2i} + [D+(1+\tau_{OTC,2}\cdot sgn \Delta X_{2i})(1-\mu\cdot sgn \Delta X_{2i})P_2]X_{1i} + 2Y_{1i}\}
- A\Var\{-(1+\tau_{OTC,2}\cdot sgn \Delta X_{2i})(1-\mu\cdot sgn \Delta X_{2i})P_2X_{2i}+T_{2i}-\gamma\}\}
\]

where \( \mathbb{1} = \begin{cases} 1 & \text{if the investor trades OTC} \\ 0 & \text{if the investor trades on-exchange} \end{cases} \).

Taking \( X_{1i} \) and prices as given, and expanding the variance terms, the FOCs in each market w.r.t. \( X_{2i} \) are:
\[
\mathbb{E}_{2i}(1+D)-2\cdot(1+\tau_{EX,2}'\cdot\text{sgn}\Delta X_{2i})P_2-AX_{2i}\text{Var}[D]-ACov_i(Z_{3i},D)=0
\]
\[
\Rightarrow -2(1+\tau_{EX,2}'\cdot\text{sgn}\Delta X_{2i})P_2+\mathbb{E}_{2i}(1+D)-ACov_i(Z_{3i},D)=X^*_2
\]

\[
\mathbb{E}_{2i}(1+D)-2\cdot(1+\tau_{OTC,2}'\cdot\text{sgn}\Delta X_{2i})(1-\mu\cdot\text{sgn}\Delta X_{2i})P_2-AX_{2i}\text{Var}[D]-ACov_i(Z_{3i},D)=0
\]
\[
\Rightarrow -2(1+\tau_{OTC,2}'\cdot\text{sgn}\Delta X_{2i})(1-\mu\cdot\text{sgn}\Delta X_{2i})P_2+\mathbb{E}_{2i}(1+D)-ACov_i(Z_{3i},D)=X^*_{OTC,2i}
\]

We can further combine these two FOCs into a single equation:
\[
\frac{2[(1+\tau_{OTC,2}'\cdot\text{sgn}\Delta X_{2i})(1-\mu\cdot\text{sgn}\Delta X_{2i})-(1+\tau_{EX,2}'\cdot\text{sgn}\Delta X_{2i})]}{A\text{Var}[D]} = X^*_{EX,2i}
\]

where I impose \(\text{sgn}\Delta X_{2i}\) be the same OTC or on-exchange. Denote \(2\alpha = \frac{2\beta_2}{A\text{Var}[D]}\) and \(\beta_2 = [(1+\tau_{OTC,2}'\cdot\text{sgn}\Delta X_{2i})(1-\mu\cdot\text{sgn}\Delta X_{2i})-(1+\tau_{EX,2}'\cdot\text{sgn}\Delta X_{2i})]=\]
\([(\tau_{OTC,2}-\mu-\tau_{EX,2}')\cdot\text{sgn}\Delta X_{2i}-\mu\tau_{OTC,2}]P_2\). A net second period buyer will choose to trade OTC iff

\[
V^*_{OTC}[W_{3i};2] = \mathbb{E}_{2i}(1+D)X_{OTC,2i}+2\mathbb{E}_{2i}\{Z_{2i}+[D+(1+\tau_{OTC,2})(1-\mu)]P_2]X_{1i}+2Y_{1i}\}
\]
\[
+2\{-1(1+\tau_{OTC,2})(1-\mu)P_{2}\cdot X_{OTC,2i}+T_{2i}^{OTC}T_{2i}\}
\]
\[
-\frac{A}{2}X_{OTC,2i}^2\text{Var}(D)-AX_{OTC,2i}\text{Cov}(Z_{3i},D)\geq
\]

\[
V^*_{EX}[W_{3i};2] = \mathbb{E}_{2i}(1+D)X_{EX,2i}+2\mathbb{E}_{2i}\{Z_{2i}+[D+(1+\tau_{EX,2})P_2]X_{1i}+2Y_{1i}\}
\]
\[
+2\{-1(1+\tau_{EX,2})P_{2}\cdot X_{EX,2i}+T_{2i}^{EX}\}
\]
\[
-\frac{A}{2}X_{EX,2i}^2\text{Var}(D)-AX_{EX,2i}\text{Cov}(Z_{3i},D)
\]

Substituting for \(X^*_{EX,2i}\):

\[
X^*_{EX,2i} \geq \alpha_2(\tau_{OTC,2}-2\tau_{EX,2})P_2 - \frac{\beta_2}{2} + \frac{\gamma}{\mu(1+\tau_{OTC,2})P_2} + X_{1i} \equiv Z_{2i}
\]

Therefore, for each individual there is a jump in the second period demand for holdings of the risky asset at (12)\(^1\). For a net seller, the inequality is simply reversed.

\(^1\)Without loss of generality, I assume the investor will choose to trade on-exchange if indifferent (i.e., if \(X^*_{EX,2i} = Z_{2i}\)).
In an equilibrium without transaction taxes in either market, the break-even point (12) simplifies to

\[ X_{EX,2i}^* \geq -\frac{[\mu P_2]^2}{A\text{Var}(D)} + \frac{\gamma}{\mu P_2} + X_{1i} \]

Moving back to period 1, the investor solves

\[ V^*[W_{3i}; 1] \equiv \max_{X_{1i}, Y_{1i}} \left[ \mathbb{E}_{1i}[C_{3i}] - \frac{A}{2}\text{Var}[C_{3i}] \right] \quad (13) \]

Once again, the investor faces two possible budget constraints

\[ Y_{1i} = [(1 + \tau_{EX,1} \cdot \text{sgn}\Delta X_{1i}) P_1] X_0 - (1 + \tau_{EX,1} \cdot \text{sgn}\Delta X_{1i}) P_1 X_{1i} + T_{EX,1i} \]

if on-exchange

\[ Y_{1i} = [(1 + \tau_{OTC,1} \cdot \text{sgn}\Delta X_{1i}) (1 - \mu \cdot \text{sgn}\Delta X_{1i}) P_1] X_0 - (1 + \tau_{OTC,1} \cdot \text{sgn}\Delta X_{1i}) (1 - \mu \cdot \text{sgn}\Delta X_{1i}) P_1 X_{1i} + T_{OTC,1i} - \gamma \text{ if OTC} \]

Substituting into (13) (as well as \( X_{2i}^* = X_{EX,2i}^* - 1_2 \alpha_2 \) and \( Y_{2i}^* \), where

\[ 1 = \begin{cases} 1 & \text{if } X_{EX,2i}^* \cdot \text{sgn}\Delta X_{2i} \geq Z_{2i} \\ 0 & \text{otherwise} \end{cases} \]

\[ V^*[W_{3i}; 1] \equiv \max_{X_{1i}, Y_{1i}} \mathbb{E}_{1i} \left[ Z_{3i} + (1 + D) X_2 + (1 + r) Y_2^* \right] \]

\[ -\frac{A}{2}\text{Var}[Z_{3i} + (1 + D) X_2 + (1 + r) Y_2^*] \]

\[ = \max_{X_{1i}, Y_{1i}} \mathbb{E}_{1i} \left[ (1 + D) \cdot \left\{ -\frac{2(1 + \tau_{EX,2} \cdot \text{sgn}\Delta X_2) P_2 + E_{2i} (1 + D) - A\text{Cov}_i (Z_{3i}, D)}{A\text{Var}[D]} \right\} - 1_2 \alpha_2 \right] \]

\[ + \mathbb{E}_{1i} \left[ 2 \cdot \left\{ (1 + \tau_{EX,2} \cdot \text{sgn}\Delta X_2) P_2 + E_{2i} (1 + D) - A\text{Cov}_i (Z_{3i}, D) \right\} \right] \]

\[ - \mathbb{E}_{1i} \left[ (1 + \tau_{EX,2} \cdot \text{sgn}\Delta X_2) P_2 + E_{2i} (1 + D) - A\text{Cov}_i (Z_{3i}, D) \right] - 1_2 \alpha_2 \]

\[ - \mathbb{E}_{1i} \left[ T_{EX,2i} + 1_2 \left[T_{OTC,2i} - T_{EX,2i}\right] \right] \]

\[ A \left\{ -\frac{2(1 + \tau_{EX,2} \cdot \text{sgn}\Delta X_2) P_2 + E_{2i} (1 + D) - A\text{Cov}_i (Z_{3i}, D)}{A\text{Var}[D]} - 1_2 \alpha_2 \right\} \]

\[ - A \left\{ -\frac{2(1 + \tau_{EX,2} \cdot \text{sgn}\Delta X_2) P_2 + E_{2i} (1 + D) - A\text{Cov}_i (Z_{3i}, D)}{A\text{Var}[D]} - 1_2 \alpha_2 \right\} \]

\[ - 2AX_{2i}^2 \text{Var}(D) - 4AX_{2i}\text{Cov}_i (Z_{2i}, D) \]
\[
V_{\text{OTC}}[W_{3i}; 1] = \max_{X_{3i}, Y_{i}} \mathbb{E} \left[ Z_{3i} + (1 + D) X_{3i}^2 + (1 + r) Y_{i}^2 \right] \\
- \frac{A}{2} \text{Var} \left[ Z_{3i} + (1 + D) X_{3i}^2 + (1 + r) Y_{i}^2 \right] \\
= \max_{X_{3i}, Y_{i}} \mathbb{E} \left[ (1 + D) \cdot \left\{ -2 (1 + \tau_{\text{EX}, 2} \cdot \text{sgn} \Delta X_{3i}) P_2 + \mathbb{E}_i (1 + D) - A \text{Cov}_i (Z_{3i}, D) \right\} \right]
\]

which gives us the FOCs with respect to \(X_{1i}^2\):

\[
- 4 \left( 1 + \tau_{\text{EX}, 1} \cdot \text{sgn} \Delta X_{1i} \right) P_1 + 2 \mathbb{E}_i \left[ D + (1 + \tau_{\text{EX}, 2} \cdot \text{sgn} \Delta X_{2i}) \right] P_2 + 2 \beta_2  \\
- 4 A X_{1i} \text{Var} \left[ D \right] - 4 A \text{Cov}_i \left[ Z_{2i}, D \right] = 0
\]

\[
\Rightarrow -2 \left( 1 + \tau_{\text{EX}, 1} \cdot \text{sgn} \Delta X_{1i} \right) P_1 + \mathbb{E}_i \left[ D + (1 + \tau_{\text{EX}, 2} \cdot \text{sgn} \Delta X_{2i}) \right] P_2 + 2 \beta_2 - 2 A \text{Cov}_i \left[ Z_{2i}, D \right] = X_{\text{EX}, 1i}^*
\]

\[
- 4 \left( 1 + \tau_{\text{OTC}, 1} \cdot \text{sgn} \Delta X_{1i} \right) \left( 1 - \mu \cdot \text{sgn} \Delta X_{1i} \right) P_1 + 2 \mathbb{E}_i \left[ D + (1 + \tau_{\text{EX}, 2} \cdot \text{sgn} \Delta X_{2i}) \right] P_2 + 2 \beta_2  \\
- 4 A X_{1i} \text{Var} \left[ D \right] - 4 A \text{Cov}_i \left[ Z_{2i}, D \right] = 0
\]

\[
\Rightarrow -2 \left( 1 + \tau_{\text{OTC}, 1} \cdot \text{sgn} \Delta X_{1i} \right) \left( 1 - \mu \cdot \text{sgn} \Delta X_{1i} \right) P_1 + \mathbb{E}_i \left[ D + (1 + \tau_{\text{EX}, 2} \cdot \text{sgn} \Delta X_{2i}) \right] P_2 + 2 \beta_2 - 2 A \text{Cov}_i \left[ Z_{2i}, D \right] = X_{\text{OTC}, 1i}^*
\]

Thus

\[
X_{\text{OTC}, 1i}^* + \frac{2 \left( 1 + \tau_{\text{OTC}, 1} \cdot \text{sgn} \Delta X_{1i} \right) \left( 1 - \mu \cdot \text{sgn} \Delta X_{1i} \right) - (1 + \tau_{\text{EX}, 1} \cdot \text{sgn} \Delta X_{1i})}{2 A \text{Var} \left[ D \right]} P_1 = X_{\text{EX}, 1i}^* 
\]

Denote \(\alpha_1 = \frac{\beta_1}{2 A \text{Var} [D]}; \beta_1 = [(1 + \tau_{\text{OTC}, 1} \cdot \text{sgn} \Delta X_{1i}) (1 - \mu \cdot \text{sgn} \Delta X_{1i}) - (1 + \tau_{\text{EX}, 1} \cdot \text{sgn} \Delta X_{1i})] P_1 \). Then

\[
X_{\text{OTC}, 1i}^* + \alpha_1 = X_{\text{EX}, 1i}^*
\]

A net first period buyer will choose to trade OTC iff
\[
V_{OTC}[W_{3,1}]=E_{t}\left[(1+D)\left\{-2(1+\tau EX_{2}^{*},sgn\Delta X_{3})P_{2}+\mathbb{E}(1+D)-ACov_{1}(Z_{3},D)\right\}\right]
\]
\[
+E_{t}\{\left\{D+(1+\tau EX_{2}^{*},sgn\Delta X_{3})P_{2}+\mathbb{I}\beta_{2}\right\}\cdot X_{OTC,11}^{*}\}
\]
\[
+4\cdot\left\{\left(1+\tau_{OTC,1}^{*},sgn\Delta X_{11}\right)P_{1}X_{0}-(1+\tau_{OTC,1}^{*},sgn\Delta X_{1})P_{1}X_{OTC,11}^{*}+\tau_{OTC,1}^{*}\gamma\right\}
\]
\[-E_{t}\left\{\left(1+\tau EX_{2}^{*},sgn\Delta X_{3})P_{2}+\mathbb{I}\beta_{2}\right\}\cdot\left\{-2(1+\tau EX_{2}^{*},sgn\Delta X_{3})P_{2}+\mathbb{E}(1+D)-ACov_{1}(Z_{3},D)\right\}\right\}
\]
\[-E_{t}\left\{\left[T_{EX,21}^{*}+\mathbb{I}\left[T_{OPT,1}^{*}-T_{EX,21}\right]\right]\right\}
\]
\[A\left\{\frac{-2(1+\tau EX_{2}^{*},sgn\Delta X_{3})P_{2}+\mathbb{E}(1+D)-ACov_{1}(Z_{3},D)}{\mathbb{E}(1+D)-ACov_{1}(Z_{3},D)}\right\}^{2}\right\}
\]
\[-\mathbb{I}\beta_{2}\cdot X_{OTC,11}^{*},\mathbb{I}\beta_{2}\cdot Cov_{1}(Z_{3},D)
\]
\[-2AX_{OTC,11}^{*},\mathbb{I}\beta_{2}\cdot Cov_{1}(Z_{3},D)
\]
\[\geq V_{EX}[W_{3,1}]=E_{t}\left[(1+D)\left\{-2(1+\tau EX_{2}^{*},sgn\Delta X_{3})P_{2}+\mathbb{E}(1+D)-ACov_{1}(Z_{3},D)\right\}\right]
\]
\[+E_{t}\{\left\{D+(1+\tau EX_{2}^{*},sgn\Delta X_{3})P_{2}+\mathbb{I}\beta_{2}\right\}\cdot X_{OTC,11}^{*}+\mathbb{I}\beta_{2}\}
\]
\[+4\cdot\left\{\left(1+\tau EX_{2}^{*},sgn\Delta X_{3})P_{2}+\mathbb{E}(1+D)-ACov_{1}(Z_{3},D)\right\}\right\}
\[-E_{t}\left\{\left[T_{EX,21}^{*}+\mathbb{I}\left[T_{OPT,1}^{*}-T_{EX,21}\right]\right]\right\}
\]
\[A\left\{\frac{-2(1+\tau EX_{2}^{*},sgn\Delta X_{3})P_{2}+\mathbb{E}(1+D)-ACov_{1}(Z_{3},D)}{\mathbb{E}(1+D)-ACov_{1}(Z_{3},D)}\right\}^{2}\right\}
\]-\mathbb{I}\beta_{2}\cdot X_{OTC,11}^{*},\mathbb{I}\beta_{2}\cdot Cov_{1}(Z_{3},D)
\]
\[\Rightarrow X_{EX,11}^{*}\geq E_{t}\left\{\frac{2\mu\epsilon\Delta X_{11}^{*},P_{1}+2(\tau_{OTC,1}^{*}+\mu(1+\tau EX_{1}^{*},sgn\Delta X_{11}^{*}P_{1})}{4\mu(1+\tau EX_{1}^{*},sgn\Delta X_{11}^{*}P_{1})}\right\}^{2}\right\}
\]

Equilibrium prices

I resume the simplifying assumptions made regarding constant dividend distribution moments and correct average aggregate price cum dividend expectations (i.e., \(\int_{i \in T} E_{ti}[D_{i+1}] = \bar{D}^{i} \)) and \(\int_{i \in T} E_{ti}(1+\tau \cdot \epsilon X_{i+1}^{*},P_{i+1}^{*} = \bar{P}_{i+1}(1+\tau \cdot \int_{i \in T} \epsilon X_{i+1}^{*},dF^{i}))\). In period 2, taking \(P_{1}^{*}\) and \(X_{11}^{*}\) as given, and using the allocations derived above, \(P_{2}\) solves the market clearing condition on-exchange:
\[
\int_{i \in \mathcal{B}} X_{EX,2i}^* - X_{1i}dF(i) = \\
- \int_{i \in \mathcal{S}} X_{EX,2i}^* - X_{1i}dF(i) \Rightarrow \\
\int_{i \in \mathcal{B}} -2(1+\tau_{EX,2}) P_2 + E_{2i}(1+D) - A\text{Cov}_i(Z_{3i},D) - X_{1i}dF(i) = \\
- \int_{i \in \mathcal{S}} -2(1-\tau_{EX,2}) P_2 + E_{2i}(1+D) - A\text{Cov}_i(Z_{3i},D) - X_{1i}dF(i) \Rightarrow \\
\int_{i \in \mathcal{T}_{EX,2}} -2(1+\tau_{EX,2} \text{sgn}\Delta X_{2i}) P_2 + E_{2i}(1+D) - A\text{Cov}_i(Z_{3i},D) - X_{1i}dF(i) = 0 \\
\Rightarrow \int_{i \in \mathcal{T}_{EX,2}} \frac{E_{2i}(1+D) - A\text{Cov}_i(Z_{3i},D) - A\text{Var}(D) X_{1i}dF(i)}{2(1+\tau_{EX,2} \text{sgn}\Delta X_{2i})} = P_2
\]

OTC takes \( P_2 \) as given from the regulated exchange. Market-clearing OTC (equivalent to \( P_{EX,2} = P_{OTC,2} = P_2 \)) is guaranteed by arbitrageurs unconstrained by \( \gamma \).\textsuperscript{16}

In period 1, similar market clearing conditions give us

\[
\int_{i \in \mathcal{B}} X_{EX,1i}^* - X_0dF(i) = \\
- \int_{i \in \mathcal{S}} X_{EX,1i}^* - X_0dF(i) \Rightarrow \\
\int_{i \in \mathcal{B}} -2(1+\tau_{EX,1} \text{sgn}\Delta X_{1i}) P_1 + E_{1i}[D + (1+\tau_{EX,2} \text{sgn}\Delta X_{2i}) P_2 + \mathbb{I}_2] - 2A\text{Cov}_i[Z_{2i},D] - X_0dF(i) = \\
- \int_{i \in \mathcal{S}} -2(1+\tau_{EX,1} \text{sgn}\Delta X_{1i}) P_1 + E_{1i}[D + (1+\tau_{EX,2} \text{sgn}\Delta X_{2i}) P_2 + \mathbb{I}_2] - 2A\text{Cov}_i[Z_{2i},D] - X_0dF(i) \Rightarrow \\
\int_{i \in \mathcal{T}_{EX}} -2(1+\tau_{EX,1} \text{sgn}\Delta X_{1i}) P_1 + E_{1i}[1+\tau_{EX,2} \text{sgn}\Delta X_{2i}) P_2 + \mathbb{I}_2] - 2A\text{Cov}_i[Z_{2i},D] - X_0dF(i) \\
+ \int_{i \in \mathcal{T}_{EX,1,OTC}} \frac{\mathbb{I}_2}{2A\text{Var}[D]} = 0 \\
\Rightarrow \int_{i \in \mathcal{T}_{EX}} \frac{E_{1i}[D + (1+\tau_{EX,2} \text{sgn}\Delta X_{2i}) P_2] - 2A\text{Cov}_i[Z_{2i},D] - 2A\text{Var}(D) X_0dF(i)}{2(1+\tau_{EX,1} \text{sgn}\Delta X_{1i})} = P_{EX,1}
\]

where \( \mathcal{T}_{EX,1,OTC} \) refers to the set of investors trading on exchange in period 1, but OTC in period 2 (and therefore with a non-zero term following the indicator function \( \mathbb{I}_2 \)). In addition, note that due to the assumed symmetry of the distribution of endowment shocks and risky returns, the set of buyers OTC in period 2 who are exchange traders in period 1 must be matched in density

\textsuperscript{16}Notice that as \( \gamma \to 0 \), in order to guarantee some trading in both markets, if \( \text{sgn}\Delta X_{2i} (<) 0 \) we must have \( P_{EX} \to [1-\mu][(1+\mu)] P_{OTC} \), so that \( \forall \gamma, P_{EX} \in [(1-\mu)P_{OTC}, (1+\mu)] \) irrespective of introducing a set of inter-market arbitrageurs.
by an equivalent set of sellers. Therefore, the last summand in (14) cancels out\textsuperscript{17}, and we have

\[
\int_{i \in T_{EX,1}} \mathbb{E}_{i} \left[ D + (1 + \tau_{EX,2} \cdot sgn \Delta X_{2i}) P_{2} - 2A \text{Cov}_{i}[Z_{2i}, D] - A \text{Var}[D] X_{0} \right] dF(i) = P_{1}
\]

Substituting for \( P_{2} \), we get

\[
\int_{i \in T_{EX,1}} \mathbb{E}_{i} \left[ D + (1 + \tau_{EX,2} \cdot sgn \Delta X_{2i}) \left\{ \int_{j \in T_{EX,2}} \frac{\mathbb{E}_{2j}(1+D)-A \text{Cov}_{2j}(Z_{2j}, D)-A \text{Var}(D) X_{1j}}{2(1 + \tau_{EX,2} \cdot sgn \Delta X_{2j})} dF(j) \right\} \right] dF(i)
\]

\[
+ \int_{i \in T_{EX,1}} \frac{-2A \text{Cov}_{i}[Z_{2i}, D] - 2A \text{Var}[D] X_{0}}{2(1 + \tau_{EX,1} \cdot sgn \Delta X_{1i})} dF(i) = P_{1}
\]

\[
\Rightarrow \int_{i \in T_{EX,1}} \mathbb{E}_{i} \left[ D + \left\{ \int_{j \in T_{EX,2}} \frac{\mathbb{E}_{2j}(1+D)-A \text{Cov}_{2j}(Z_{2j}, D)-A \text{Var}(D) X_{1j}}{2(1 + \tau_{EX,2} \cdot sgn \Delta X_{2j})} dF(j) \right\} \right] dF(i)
\]

\[
+ \int_{i \in T_{EX,1}} \frac{-2A \text{Cov}_{i}[Z_{2i}, D] - 2A \text{Var}[D] X_{0}}{2(1 + \tau_{EX,1} \cdot sgn \Delta X_{1i})} dF(i) = P_{1}
\]

\[
\Rightarrow \int_{i \in T_{EX,1}} \mathbb{E}_{i} \left[ 2D + \left\{ \int_{j \in T_{EX,2}} \frac{\mathbb{E}_{2j}(1+D)-A \text{Cov}_{2j}(Z_{2j}, D)-A \text{Var}(D) X_{1j}}{2(1 + \tau_{EX,2} \cdot sgn \Delta X_{2j})} dF(j) \right\} \right] dF(i)
\]

\[
+ \int_{i \in T_{EX,1}} \frac{-4A \text{Cov}_{i}[Z_{2i}, D] - 4A \text{Var}[D] X_{0}}{4(1 + \tau_{EX,1} \cdot sgn \Delta X_{1i})} dF(i) = P_{1}
\]

\text{(15)}

Marginal change in individual certainty equivalent due to the tax

The investor’s certainty equivalent is given by

\textsuperscript{17}Note the term \( sgn \Delta X_{1i} \) in the denominator is integrated with respect to the entire set of exchange traders in period 1, and thus does not interfere with the entire summand equaling zero.
\[ \hat{V}_i = E_i \left[ Z_{3i}^0 + (1+D)(X_{EX,2i-1}\alpha_2) \right] \\
+ E_i \left[ 2 \left\{ Z_{2i}^0 + [D+(1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2+\mathbb{I}_2\beta_2](X_{EX,1i-1}\alpha_1) \right\} \right] \\
+ 4E_i \left\{ \left\{ [1+\tau_{EX,2}\cdot sgn \Delta X_{2i}]P_1+\mathbb{I}_1 \begin{pmatrix} \beta_1 \\ -\mu \cdot sgn \Delta X_{2i}P_1 \end{pmatrix} \right\} (X_{0}-(X_{EX,1i-1}\alpha_1)+\mathbb{I}_1\gamma) \right\} \\
- 2E_i(1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2+\mathbb{I}_2\beta_2)(X_{EX,2i-1}\alpha_2)+2T_{2i}^0-2I_2\gamma \\
- \frac{A}{2} Var \left[ Z_{3i}^0 + (1+D)(X_{EX,2i-1}\alpha_2) \right] \\
- \frac{A}{2} Var \left[ 2 \left\{ Z_{2i}^0 + [D+(1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2](X_{EX,1i-1}\alpha_1) \right\} \right] \\
= E_i[(1+D)(X_{EX,2i-1}\alpha_2)] \\
+ E_i[2 \left\{ [D+(1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2+\mathbb{I}_2\beta_2](X_{EX,1i-1}\alpha_1) \right\} ] \\
+ 4E_i \left\{ (1-\mathbb{I}_1\mu \cdot sgn \Delta X_{1i})P_1(X_{0}-(X_{EX,1i-1}\alpha_1)) - \mathbb{I}_1\gamma \right\} \\
- 2E_i(1+\tau_{EX,2}\cdot sgn \Delta X_{2i})P_2+\mathbb{I}_2\beta_2)(X_{EX,2i-1}\alpha_2)-2I_2\gamma \\
- \frac{A}{2} Var(D)(X_{EX,2i-1}\alpha_2)^2 \\
- \frac{A}{2} Cov_i(Z_{3i},D)2(X_{EX,2i-1}\alpha_2) \\
- \frac{A}{2} Var(D)4(X_{EX,1i-1}\alpha_1)^2 \\
- \frac{A}{2} Cov_i(Z_{2i},D)8(X_{EX,1i-1}\alpha_1) \\
\]

where I have substituted for \( Y_{2i} \) and \( Y_{1i} \) using the respective period’s budget constraints. Holding \( \tau_{OTC} \) constant, a marginal change in \( \tau_{EX} \) translates into
\[ \frac{d\hat{V}_i}{d\tau_{EX}} = 2\text{sgn}\Delta X_{2i}P_2 [(X_{EX,1i} - \theta_1\alpha_1) - (X_{EX,2i} - \theta_2\alpha_2)] \\
\] 
\[ -\text{sgn}\Delta X_{2i}P_2 + [(\tau_{OTC,2} - \mu - \tau_{EX,2}) \cdot \text{sgn}\Delta X_{2i} - \mu \tau_{OTC,2}] \cdot \frac{dP_2}{d\tau_{EX}} \\
+ \frac{d\beta_2}{\partial \tau_{EX}} - 2 \{(X_{EX,1i} - \theta_1\alpha_1) - (X_{EX,2i} - \theta_2\alpha_2)\} \theta_2 \\
- \frac{2\text{sgn}\Delta X_{2i}P_2}{AVar(D)} \\
+ \frac{\partial \alpha_2}{\partial \tau_{EX}} \cdot [-(1+D)\theta_2 + 2[(1+\tau_{EX,2} \cdot \text{sgn}\Delta X_{2i})P_2 + \theta_2\beta_2] \theta_2] \\
+ \frac{\partial \alpha_2}{\partial P_2} \cdot [-\frac{(1+D)\tau_2}{P_2}] \\
+ \frac{dP_2}{d\tau_{EX}} \cdot \frac{\partial \alpha_2}{\partial P_2} \cdot [AVar(D)X_{EX,2i} \theta_2 - AVar(D)\theta_2\alpha_2 + A\text{Cov}(Z_{3i}, D)\theta_2] \\
+ \frac{d\theta_2}{d\alpha_2} \cdot [\{X_{EX,1i} - \theta_1\alpha_1\} - (X_{EX,2i} - \theta_2\alpha_2)] \\
\] 
\[ + \frac{d\theta_2}{d\alpha_2} \cdot [2(1+\tau_{EX,2} \cdot \text{sgn}\Delta X_{2i})P_2 \alpha_2 + \theta_2\beta_2 \alpha_2] \\
+ \frac{d\theta_2}{d\alpha_2} \cdot [AVar(D)X_{EX,2i} \alpha_2 - AVar(D)\theta_2\alpha_2 + A\text{Cov}(Z_{3i}, D)\alpha_2 - \gamma] \]
In turn, the marginal change in the certainty equivalent caused by introducing \( \tau_{OTC} \) is
\[
\frac{d\dot{V}_i}{d\tau_{OTC}} = \frac{d^2}{d\tau_{OTC}^2} \left[ \text{sgn}\Delta X_{2i} P_2 - \mu P_2 + [(\tau_{OTC,2} - \tau_{EX,2}) \cdot \text{sgn}\Delta X_{2i} - \mu \tau_{OTC,2}] \right] \cdot \frac{dP_2}{d\tau_{OTC}} \\
+ \frac{\partial^2}{\partial \tau_{OTC}^2} \left[ -(1 + D) \theta_2 + 2[(1 + \tau_{EX,2} \cdot \text{sgn}\Delta X_{2i}) P_2 + \theta_2 \beta_2] \theta_2 \right] \\
+ \frac{\partial^2}{\partial \tau_{OTC}^2} \left[ A\text{Var}(D) X_{EX,2i} \theta_2 - A\text{Var}(D) \theta_2 \alpha_2 + A\text{Cov}_i(Z_3i, D) \theta_2 \right] \\
+ \frac{dP_2}{d\tau_{OTC}} \cdot \frac{\partial^2}{\partial \tau_{OTC}^2} \left[ -(1 + D) \theta_2 + 2[(1 + \tau_{EX,2} \cdot \text{sgn}\Delta X_{2i}) P_2 + \theta_2 \beta_2] \theta_2 \right] \\
+ \frac{dP_2}{d\tau_{OTC}} \cdot \frac{\partial^2}{\partial \tau_{OTC}^2} \left[ A\text{Var}(D) X_{EX,2i} \theta_2 - A\text{Var}(D) \theta_2 \alpha_2 + A\text{Cov}_i(Z_3i, D) \theta_2 \right] \\
+ \frac{dX_{EX,2i}}{d\tau_{OTC}} \left[ (1 + D - 2[(1 + \tau_{EX,2} \cdot \text{sgn}\Delta X_{2i}) P_2 + \theta_2 \beta_2]) \right] \\
+ \frac{dX_{EX,2i}}{d\tau_{OTC}} \left[ -A\text{Var}(D) X_{EX,2i} + A\text{Var}(D) \theta_2 \alpha_2 - A\text{Cov}_i(Z_3i, D) \right] \\
+ \frac{d\theta_2}{d\tau_{OTC}} \left[ -(1 + D) \alpha_2 + 2\beta_2 \{(X_{EX,1i} - \theta_1 \alpha_1) - (X_{EX,2i} - \theta_2 \alpha_2)\} \right] \\
+ \frac{d\theta_2}{d\tau_{OTC}} \left[ 2(1 + \tau_{EX,2} \cdot \text{sgn}\Delta X_{2i}) P_2 \alpha_2 + 2\theta_2 \beta_2 \alpha_2 \right] \\
+ \frac{d\theta_2}{d\tau_{OTC}} \left[ A\text{Var}(D) X_{EX,2i} \alpha_2 - A\text{Var}(D) \theta_2 \alpha_2 + A\text{Cov}_i(Z_3i, D) \alpha_2 \right]
\]
Derivation of Social Planner’s FOCs

Given the optimization problem introduced in section 2.3, the FOCs with respect to $\tau_{EX}$ and $\tau_{OTC}$ can be expressed as
\[
\int \lambda E \left[ U_i(W_{\alpha i}) \right] \text{d}\vec{V}_i \text{ w.r.t. } \tau_{EX}
\]

\[
-\delta \left[ P_2 \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \{ (X_{EX,2i}-\theta_2 \alpha_2)-(X_{EX,11}-\theta_1 \alpha_1) \} \{ 1-\theta_2 \} \text{d}F(i) \right]
\]

\[
-\delta \frac{dP_2}{d\tau_{EX}} \left[ (\tau_{EX}+\theta_2(\tau_{OTC}-\tau_{EX})) \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \left\{ \frac{dX_{EX,2i}}{d\tau_{EX}} - \theta_2 \frac{\partial \alpha_2}{\partial \tau_{EX}} \text{d}F(i) \right\} \right]
\]

\[
-\delta \left[ (\tau_{OTC}-\tau_{EX}) \frac{dP_2}{d\tau_{EX}} \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \{ (X_{EX,2i}-\theta_2 \alpha_2)-(X_{EX,11}-\theta_1 \alpha_1) \} \text{d}F(i) \right]
\]

\[
+\delta \left[ (\tau_{EX}+\theta_2(\tau_{OTC}-\tau_{EX})) \frac{dP_2}{d\tau_{EX}} \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \alpha_2 \text{d}F(i) \right]
\]

\[
-\delta \left[ (\tau_{EX}+\theta_2(\tau_{OTC}-\tau_{EX})) \frac{dP_2}{d\tau_{EX}} \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \alpha_1 \text{d}F(i) \right]
\]

\[
-\delta \left[ (\tau_{EX}+\theta_2(\tau_{OTC}-\tau_{EX})) \frac{dP_2}{d\tau_{EX}} \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \theta_1 \text{d}F(i) \right]
\]

\[
+\delta \left[ (\tau_{EX}+\theta_2(\tau_{OTC}-\tau_{EX})) \frac{dP_2}{d\tau_{EX}} \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \frac{dX_{EX,11}}{d\tau_{EX}} \text{d}F(i) = 0 \right]
\]

and

\[
(16)
\]
\[
\int \lambda_i \mathbb{E} \left[ U_i (W_{3i}) \right] \left\{ \frac{d\hat{V}_i}{d\tau_{OC}} \right\} dF(i) \text{ w.r.t. } \tau_{OC}
\]

\[
-\delta \left[ \iota_2 \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \left\{ (X_{EX,2i} - \theta_2 \alpha_2) - (X_{EX,1i} - \theta_1 \alpha_1) \right\} \theta_2 dF(i) \right]
\]

\[
-\delta \frac{dP_2}{d\tau_{OC}} \left[ \tau_{EX,2i} + \theta_2 (\tau_{OC} - \tau_{EX}) \right] \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \left\{ (X_{EX,2i} - \theta_2 \alpha_2) - (X_{EX,1i} - \theta_1 \alpha_1) \right\} \frac{\frac{\partial P_2}{\partial \tau_{OC}}}{\partial \tau_{OC}} dF(i)
\]

\[
-\delta \left[ (\tau_{OC} - \tau_{EX}) P_2 \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \left\{ (X_{EX,2i} - \theta_2 \alpha_2) - (X_{EX,1i} - \theta_1 \alpha_1) \right\} dF(i) \right] \frac{\frac{\partial \theta_2}{\partial \tau_{OC}}}{d\tau_{OC}} dF(i)
\]

\[
+\delta \left[ \tau_{EX,2i} + \theta_2 (\tau_{OC} - \tau_{EX}) \right] \iota_2 \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \alpha_2 \frac{\partial \theta_2}{\partial \tau_{OC}} dF(i)
\]

\[
-\delta \left[ \tau_{EX,2i} + \theta_2 (\tau_{OC} - \tau_{EX}) \right] \iota_2 \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \alpha_1 \frac{\partial \theta_1}{\partial \tau_{OC}} dF(i)
\]

\[
-\delta \left[ \tau_{EX,2i} + \theta_2 (\tau_{OC} - \tau_{EX}) \right] \iota_2 \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \alpha_1 \frac{\partial \theta_1}{\partial \tau_{OC}} dF(i)
\]

\[
+\delta \left[ \tau_{EX,2i} + \theta_2 (\tau_{OC} - \tau_{EX}) \right] \iota_2 \int_{i \in T} \text{sgn}(\Delta X_{EX,2i}) \alpha_1 \frac{\partial \theta_1}{\partial \tau_{OC}} dF(i)
\]

\[
\frac{\partial \theta_1}{\partial \tau_{OC}} dF(i) = 0 \quad (17)
\]

Denote \[ \lambda_i \mathbb{E} \left[ U_i (W_{3i}) \right] = g_i. \] Starting from equation (16), substituting for \[ \frac{d\hat{V}_i}{d\tau_{EX}} \] and expanding for \[ \Delta X_{ti}, \] we get
which then can be simplified to
Similarly, starting from equation (17), we get

\[ -2P_2 \int_{i \in T} g_i \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] (1 - \theta_2) dF(i) \]
\[ -\delta \cdot \tau_{OTC} P_2 \int_{i \in T} \frac{d\theta_2}{d\tau_{EX}} \cdot \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] dF(i) \]
\[ +\delta \cdot \tau_{EX} P_2 \int_{i \in T} \frac{d\theta_2}{d\tau_{EX}} \cdot \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] dF(i) \]
\[ +2\tau_{EX} P_2 \int_{i \in T} g_i \frac{d\theta_2}{d\tau_{EX}} \cdot \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] dF(i) \]
\[ -2\tau_{OTC} P_2 \int_{i \in T} g_i \frac{d\theta_2}{d\tau_{EX}} \cdot \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] dF(i) \]
\[ +2\mu P_2 \int_{i \in T} g_i \frac{d\theta_2}{d\tau_{EX}} \cdot \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] dF(i) \]
\[ +2\mu \tau_{OTC} P_2 \int_{i \in T} g_i \frac{d\theta_2}{d\tau_{EX}} [\Delta X_{T,2i}] dF(i) \]
\[ -2\gamma \int_{i \in T} g_i \frac{d\theta_2}{d\tau_{EX}} dF(i) \]
\[ -4\gamma \int_{i \in T} g_i \frac{d\theta_1}{d\tau_{EX}} dF(i) \]
\[ -2\tau_{EX} \frac{dP_2}{d\tau_{EX}} \int_{i \in T} g_i \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] (1 - \theta_2) dF(i) \]
\[ -\frac{dP_2}{d\tau_{EX}} - 2 \int_{i \in T} g_i (1 + \theta_2 (\tau_{OTC} - \mu) \cdot \text{sgn} \Delta X_{2i}) [\Delta X_{T,2i}] dF(i) \]
\[ +2\mu \tau_{OTC} \frac{dP_2}{d\tau_{EX}} \int_{i \in T} g_i [\Delta X_{T,2i}] \theta_2 dF(i) \]
\[ -\frac{dP_1}{d\tau_{EX}} - 4 \int_{i \in T} g_i [1 - \theta_1 \mu \cdot \text{sgn} \Delta X_{1i}] [\Delta X_{T,1i}] dF(i) \]
\[ -\delta \cdot \tau_{EX} \cdot \frac{dP_2}{d\tau_{EX}} \int_{i \in T} \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] (1 - \theta_2) dF(i) \]
\[ -\delta \cdot \tau_{EX} \cdot \frac{dP_2}{d\tau_{EX}} \int_{i \in T} \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] (1 - \theta_2) dF(i) \]
\[ -\delta \cdot \tau_{OTC} \frac{dP_2}{d\tau_{EX}} \int_{i \in T} \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] \theta_2 dF(i) \]
\[ -\delta \cdot \tau_{EX} \cdot P_2 \int_{i \in T} \text{sgn} \Delta X_{EX,2i} \frac{dX_{EX,2i}}{d\tau_{EX}} - \frac{d\theta_2}{d\tau_{EX}} \cdot \frac{dX_{EX,1i}}{d\tau_{EX}} \frac{d\theta_1}{d\tau_{EX}} \frac{\Delta X_{EX,2i}}{d\tau_{EX}} (1 - \theta_2) dF(i) \]
\[ -\delta \cdot \tau_{OTC} \cdot P_2 \int_{i \in T} \text{sgn} \Delta X_{EX,2i} \frac{dX_{EX,2i}}{d\tau_{EX}} - \frac{d\theta_2}{d\tau_{EX}} \cdot \frac{dX_{EX,1i}}{d\tau_{EX}} \frac{d\theta_1}{d\tau_{EX}} \frac{\Delta X_{EX,2i}}{d\tau_{EX}} \theta_2 dF(i) = 0 \]
-2\delta \tau_{OTC} P_2 \int_{i \in T} g_i sgn(\Delta X_{i,2}) [\Delta X_{T,2}] dF(i)
+2\tau_{EX} P_2 \int_{i \in T} g_i sgn(\Delta X_{i,2}) dF(i)
-2\tau_{OTC} P_2 \int_{i \in T} g_i sgn(\Delta X_{i,2}) dF(i)
+2\mu P_2 \int_{i \in T} g_i sgn(\Delta X_{i,2}) dF(i)
+2\mu \tau_{OTC} P_2 \int_{i \in T} g_i d\theta_{2} d\tau_{OTC} [\Delta X_{T,2}] dF(i)
-2\gamma P_2 \int_{i \in T} g_i d\theta_{1} d\tau_{OTC} [\Delta X_{T,2}] dF(i)
-2\delta \tau_{EX} P_2 \int_{i \in T} g_i sgn(\Delta X_{i,2}) [\Delta X_{T,2}] dF(i)
+2\delta \tau_{OTC} P_2 \int_{i \in T} g_i sgn(\Delta X_{i,2}) [\Delta X_{T,2}] dF(i)

which simplifies to
we can derive the formula for the exact values of

\[ -2P_2 \int_{i \in T} g_i \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] \theta_2 dF(i) \]

\[ -\delta \tau_{OTC} P_2 \int_{i \in T} \frac{d \theta_2}{d \tau_{OTC}} \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] dF(i) \]

\[ + \delta \tau_{EX} P_2 \int_{i \in T} \frac{d \theta_2}{d \tau_{OTC}} \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] dF(i) \]

\[ + 2 \tau_{EX} P_2 \int_{i \in T} g_i \text{sgn} \Delta X_{2i} \frac{d \theta_2}{d \tau_{OTC}} [\Delta X_{T,2i}] dF(i) \]

\[ - 2 \tau_{OTC} P_2 \int_{i \in T} g_i \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] dF(i) \]

\[ + 2 \mu P_2 \int_{i \in T} g_i \frac{d \theta_2}{d \tau_{OTC}} [\Delta X_{T,2i}] dF(i) \]

\[ + 2 \mu \tau_{OTC} P_2 \int_{i \in T} g_i \frac{d \theta_2}{d \tau_{OTC}} [\Delta X_{T,2i}] dF(i) \]

\[ - 2 \gamma \int_{i \in T} g_i \frac{d \theta_2}{d \tau_{OTC}} dF(i) \]

\[ - 4 \gamma \int_{i \in T} g_i \frac{d \theta_2}{d \tau_{OTC}} dF(i) \]

\[ -2 \frac{d P_2}{d \tau_{OTC}} \int_{i \in T} g_i [\Delta X_{T,2i}] dF(i) \]

\[ - \tau_{EX} \frac{d P_2}{d \tau_{OTC}} \int_{i \in T} g_i \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] (1 - \theta_2) dF(i) \]

\[ - \tau_{OTC} \frac{d P_2}{d \tau_{OTC}} \int_{i \in T} g_i \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] \theta_2 dF(i) \]

\[ + \mu \frac{d P_2}{d \tau_{OTC}} \int_{i \in T} g_i \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] \theta_2 dF(i) \]

\[ + 2 \mu \tau_{OTC} \frac{d P_2}{d \tau_{OTC}} \int_{i \in T} g_i [\Delta X_{T,2i}] \theta_2 dF(i) \]

\[ - 4 \frac{d P_1}{d \tau_{OTC}} \int_{i \in T} g_i [1 - \mu \theta_1 \text{sgn} \Delta X_{1i}] [\Delta X_{T,1i}] dF(i) \]

\[ - \delta \frac{P_1}{d \tau_{OTC}} \int_{i \in T} \text{sgn} \Delta X_{2i} [\Delta X_{T,2i}] \theta_2 dF(i) \]

\[ - \delta \tau_{EX} P_2 \int_{i \in T} \text{sgn} \Delta X_{2i} \left[ \frac{d X_{EX,2i}}{d \tau_{OTC}} - \frac{d \theta_2}{d \tau_{OTC}} \left( \frac{d X_{EX,1i}}{d \tau_{EX}} - \frac{d \theta_1}{d \tau_{OTC}} \right) \right] (1 - \theta_2) dF(i) \]

\[ - \delta \tau_{OTC} P_2 \int_{i \in T} \text{sgn} \Delta X_{2i} \left[ \frac{d X_{EX,2i}}{d \tau_{OTC}} - \frac{d \theta_2}{d \tau_{OTC}} - \left( \frac{d X_{EX,1i}}{d \tau_{EX}} - \frac{d \theta_1}{d \tau_{OTC}} \right) \right] \theta_2 dF(i) = 0 \] (19)

Finally, using the FOC with respect to \( \delta \), the multiplier of the government budget constraint, we can derive the formula for the exact values of \( \tau_{EX}^* \) and \( \tau_{OTC}^* \) given some target revenue level \( R \). Starting from the FOC:

\[ 2P_2 \int_{i \in B} \{ (1 - \theta_2) \tau_{EX} + \theta_2 \tau_{OTC} \} \cdot \Delta X_{B,2i} dF(i) = R \]
and substituting for (2.18), we have

\[
2P_2 \int_{\tilde{\psi}} \left\{ \tau_{\text{EX}}(1-\theta_2) + \theta_2 \left( \frac{\eta_{\text{OTC}} - \tau_{\text{EX}} \psi_{\text{OTC}} \int_{\psi} (1-\theta_2) dF(i) + \kappa_{\text{EX}}}{\psi_{\text{OTC}} \int_{\psi} \theta_2 dF(i)} \right) \right\} \Delta X_{B,2;1} dF(i) = R
\]

\[
\Rightarrow 2P_2 \tau_{\text{EX}} \int_{\tilde{\psi}} \left( - \frac{\kappa_{\text{EX}}}{\psi_{\text{OTC}} \int_{\psi} \theta_2 dF(i)} \right) \Delta X_{B,2;1} dF(i) = R - \frac{\eta_{\text{OTC}}}{\psi_{\text{OTC}}} 2P_2 \int_{\tilde{\psi}} \Delta X_{T,2} dF(i)
\]

\[
\Rightarrow \tau_{\text{EX}} = - \frac{\psi_{\text{OTC}} \int_{\psi} \theta_2 dF(i)}{2P_2 \int_{\tilde{\psi}} \Delta X_{B,2;1} dF(i) \cdot \kappa_{\text{EX}}} + \frac{\eta_{\text{OTC}} \int_{\psi} \theta_2 dF(i)}{\kappa_{\text{EX}}}
\]

(20)

Omitting the terms of \( \eta_{\text{EX}} \) and \( \eta_{\text{OTC}} \) pertaining to the distortion in OTC rents, note that

\[
\eta_{\text{EX}} = \tau_{\text{EX}}^* \psi_{\text{EX}} \int_{\tilde{\psi}} (1-\theta_2) dF(i) + \tau_{\text{OTC}}^* \left\{ \psi_{\text{EX}} \int_{\tilde{\psi}} \theta_2 dF(i) + \kappa_{\text{OTC}} \right\}
\]

\[
= 2P_2 \int_{\tilde{\psi}} \left[ \Delta X_{B,2;1} (1-\theta_2) dF(i) \right] \left( 2 \int_{\tilde{\psi}} g_i dF(i) + \delta \right)
\]

\[
\Rightarrow \frac{\tau_{\text{EX}}^* \psi_{\text{EX}} \int_{\tilde{\psi}} (1-\theta_2) dF(i) + \tau_{\text{OTC}}^* \left\{ \psi_{\text{EX}} \int_{\tilde{\psi}} \theta_2 dF(i) + \kappa_{\text{OTC}} \right\}}{2P_2 \int_{\tilde{\psi}} \Delta X_{B,2;1} (1-\theta_2) dF(i)} = \left[ 2 \int_{\tilde{\psi}} g_i dF(i) + \delta \right]
\]

and

\[
\eta_{\text{OTC}} = \tau_{\text{OTC}}^* \psi_{\text{OTC}} \int_{\tilde{\psi}} \theta_2 dF(i) + \psi_{\text{EX}} \left( \psi_{\text{EX}} \int_{\tilde{\psi}}(1-\theta_2) dF(i) + \kappa_{\text{EX}} \right)
\]

\[
= 2P_2 \int_{\tilde{\psi}} \left[ \Delta X_{B,2;1} \theta_2 dF(i) \right] \left( 2 \int_{\tilde{\psi}} g_i dF(i) + \delta \right)
\]

\[
\Rightarrow \frac{\tau_{\text{OTC}}^* \psi_{\text{OTC}} \int_{\tilde{\psi}} \theta_2 dF(i) + \psi_{\text{EX}} \int_{\tilde{\psi}}(1-\theta_2) dF(i) + \kappa_{\text{EX}}}{2P_2 \int_{\tilde{\psi}} \Delta X_{B,2;1} \theta_2 dF(i)} = \left[ 2 \int_{\tilde{\psi}} g_i dF(i) + \delta \right]
\]

Therefore

\[
\tau_{\text{EX}}^* \psi_{\text{EX}} \int_{\tilde{\psi}} (1-\theta_2) dF(i) + \tau_{\text{OTC}}^* \left( \psi_{\text{EX}} \int_{\tilde{\psi}} \theta_2 dF(i) + \kappa_{\text{OTC}} \right) = \frac{2P_2 \int_{\tilde{\psi}} \Delta X_{B,2;1} (1-\theta_2) dF(i)}{2P_2 \int_{\tilde{\psi}} \Delta X_{B,2;1} \theta_2 dF(i)}
\]

\[
\tau_{\text{EX}}^* \left\{ \psi_{\text{OTC}} \int_{\tilde{\psi}} (1-\theta_2) dF(i) + \kappa_{\text{EX}} \right\} + \tau_{\text{OTC}}^* \psi_{\text{OTC}} \int_{\tilde{\psi}} \theta_2 dF(i) = \frac{\psi_{\text{OTC}} \int_{\tilde{\psi}} (1-\theta_2) dF(i) + \kappa_{\text{EX}}}{2P_2 \int_{\tilde{\psi}} \Delta X_{B,2;1} \theta_2 dF(i)}
\]

\[
\Rightarrow \tau_{\text{OTC}}^* \left\{ \psi_{\text{OTC}} \int_{\tilde{\psi}} (1-\theta_2) dF(i) + \kappa_{\text{OTC}} \right\} = \frac{\psi_{\text{OTC}} \int_{\tilde{\psi}} (1-\theta_2) dF(i) + \kappa_{\text{OTC}}}{2P_2 \int_{\tilde{\psi}} \Delta X_{B,2;1} \theta_2 dF(i)}
\]

\[
\tau_{\text{OTC}}^* = \tau_{\text{EX}}^* \left\{ \frac{\psi_{\text{EX}} \int_{\tilde{\psi}} (1-\theta_2) dF(i) + \psi_{\text{OTC}} \int_{\tilde{\psi}} (1-\theta_2)^2 dF(i) + \int_{\tilde{\psi}} (1-\theta_2) dF(i) \kappa_{\text{EX}}}{\psi_{\text{OTC}} \int_{\tilde{\psi}} \theta_2 (1-\theta_2) dF(i) + \psi_{\text{EX}} \int_{\tilde{\psi}} \theta_2^2 dF(i) + \int_{\tilde{\psi}} \theta_2 dF(i) \kappa_{\text{OTC}}} \right\}
\]
Equation (20) can thus be rewritten as

\[
\begin{align*}
R &= 2P_2 \int_{i \in B} \left\{ \tau_{EX} (1-\theta_2) + \theta_2 \tau_{EX} \left[ \frac{\psi_{EX} \int_{i \in T} (1-\theta_2) \theta_2 dF(i) + \psi_{OTC} \int_{i \in T} (1-\theta_2)^2 dF(i) + \int_{i \in T} (1-\theta_2) dF(i) \kappa_{EX}}{\psi_{OTC} \int_{i \in T} \theta_2 (1-\theta_2) dF(i) + \psi_{EX} \int_{i \in T} \theta_2 dF(i) + \kappa_{OTC}} \right] \right\} \Delta X_{B,2} dF(i) \\
&\Rightarrow 2P_2 \tau_{EX} \int_{i \in B} \left\{ \frac{2\psi_{OTC} \int_{i \in T} (1-\theta_2)^2 dF(i) + 2\psi_{EX} \int_{i \in T} \theta_2 (1-\theta_2) dF(i) + \int_{i \in T} (1-\theta_2) dF(i) \kappa_{OTC} + \kappa_{EX}}{\psi_{OTC} \int_{i \in T} (1-\theta_2) dF(i) + \psi_{EX} \int_{i \in T} \theta_2 dF(i) + \kappa_{OTC}} \right\} \Delta X_{B,2} dF(i) = R \\
&\Rightarrow \tau_{EX} = R \frac{2P_2 \int_{i \in B} \Delta X_{B,2} dF(i)}{\left\{ 2\psi_{OTC} \int_{i \in T} (1-\theta_2)^2 dF(i) + 2\psi_{EX} \int_{i \in T} \theta_2 (1-\theta_2) dF(i) + \int_{i \in T} (1-\theta_2) dF(i) \kappa_{OTC} + \kappa_{EX} \right\}}
\end{align*}
\]
.3 Appendix for Chapter 3

Fuzzy regression discontinuity

Several papers have exploited the discrete jump in probability of receiving Objective 1 transfers in a regression discontinuity design (Kallstrom (2014); Pellegrini et al. (2013)), though the most cited reference in this line of literature (and also the first one to really explore this design) remains Becker et al. (2010). As summarized earlier, the authors use a binary treatment variable (whether or not a NUTS 2 region was eligible for Objective 1 transfers) to estimate the local average treatment effect of structural funds on average GDP growth and employment within a programming period. The analysis below aims at mirroring the strategy used by Becker et al. (2010), but addressing a couple of its limitations which the data used in the panel instrumental variables exercise above enables me to do. In particular, instead of binary treatment, I use a continuous treatment variable (actual expenditures received), that is furthermore instrumented as in the panel IV above by corresponding commitments; the same rationale for instrumenting applies as before (endogeneity in expenditures with respect to aggregate demand conditions and measurement error). In addition, although the nature of the quasi-experimental design does arise from a discontinuity in eligibility for Objective 1 funds, I use the total amount of funds transferred to regions (including Objective 2 funds) as my treatment variable; the reason behind this choice is that using merely Objective 1 transfers implicitly attributes 0 valued transfers to most regions on the right-side of the discontinuity threshold, thus exacerbating the true treatment discontinuity\(^{18}\) and underestimating any existing treatment effect. As in robustness Table 3.10, I find some evidence of weaker treatment effects in the 2007-13 period, due likely to the particular choice of fiscal shock identification in levels - a necessary evil of the regression discontinuity criterion.

Although I have data on annual commitments and expenditures by NUTS 2 region\(^{19}\), the treatment assignment variable (running variable in the regression discontinuity created by the threshold of eligibility for Obj.1 funds, i.e. reference period GDP per capita) is unique per programming period. Thus, in what follows I estimate the local average treatment effect of Obj.1 fund eligibility separately for each

\(^{18}\)Objective 2 regions also do receive some transfers. Although not as sizable as median Objective 1 transfers, the former are still “treated” observations, even while being a valid control group for Objective 1 regions. That continuity in treatment beyond the Objective 1 threshold is a feature often neglected by previous literature using the methodology in this section.

\(^{19}\)There is also data on expenditures at the NUTS3 level for the 2000-06 period, but instruments exist at the NUTS 2 level only (by design). See Becker et al. (2012), who use this shorter period but more disaggregated dataset in a generalized propensity score setup.
programming period (the samples can of course also be pooled, treating each region as a separate region-programming period unit).

From the graphs below, it is apparent that we are dealing with a fuzzy discontinuity, since there are a few Obj.1 regions above the eligibility threshold. However, most regions receiving positive funds above that threshold are Obj.2 regions. Thus, a simple binary treatment regression discontinuity local average treatment effect estimation would vastly underestimate any actual effects, by imputing zero treatment on Obj.2 regions which actually get some federal funding (albeit significantly smaller than the Obj.1 sample on average). In addition, it is worthwhile noting that several Obj.1 regions are allocated funds at per capita levels comparable to Obj.2 regions - in other words, Obj.1 treatment is highly heterogeneous, and comparisons should be made between those with high levels of transfers and regular Obj.2 regions, conditional on similar reference period GDP per capita, rather than all regions within a given band of the threshold.

For the “normal” 2000-06 programming period, we can see the graphical evidence in Figure .16 in support of a regression discontinuity design below: commitments (per capita and as a share of initial GDP) show a discontinuity and change in slope (interaction effect) at the eligibility threshold with respect to the assignment variable (reference-period GDP per capita). However, when looking at the outcome variable (average real GDP growth), it is difficult to see such a discontinuity - if anything, my evidence goes in the opposite direction from that found by Becker et al. (2010), in that growth outcomes are slightly lower immediately before the threshold relative to those immediately after. This is apparent using linear fits or 5th order asymmetric
polynomials on both sides of the threshold. Note in this graphical evidence I am using commitments, rather than expenditures as treatment, since the latter can be driven by local demand conditions (this was in fact the core motivation underlying our earlier broad sample IV estimation). Graphically, however, expenditures and commitments behave alike with respect to the assignment variable.

Since I have a continuous treatment variable with noncompliers to the treatment assignment rule (fuzzy design), the RD naturally has to be estimated in two stages. In addition to using a binary indicator of whether a region is above or below the
Figure .15: Funds committed (for entire programming period) as a share of initial annual GDP: 2000-06 programming period

Figure .16: Average annual GDP per capita growth by treatment eligibility: 2000-06 programming period, EU-12 only
threshold (the typical exclusive instrument for treatment in this setup), I add the respective commitments series as an additional instrument. In particular, the second stage specification is

\[
\frac{Y_{i,t} - Y_{i,t-1}}{Y_{i,t-1}} = \gamma_t + \alpha_j + \phi G_{it} + g(F_{it}) + \xi_{it}
\]

where in the first stage I estimate

\[
G_{it} = \theta_t + \nu_j + \delta_1 [F_{it} > 0] + \beta C_{it} + f(F_{it}) + \epsilon_{it}
\]

\(g(F_{it})\) and \(f(F_{it})\), functions of the forcing variable \(F_{it}\), are approximated by asymmetric polynomials on each side of the threshold, including interaction terms. In what follows, I treat the data as a pooled cross-section for each programming period, although year and country fixed effects are used, just as for the panel estimates above\(^{20}\). I estimate the treatment assignment function in the first stage via 3rd/5th

---

\(^{20}\)The results are robust to their exclusion.
degree asymmetric polynomial approximation of the total funds spent in a given programming period around the threshold\textsuperscript{21}. The outcome variable then on the second stage is the annual GDP per capita growth rate over the respective years.

While I find a large LATE consistent with the IV results above for the 2000-06 period (consistent with the findings of Becker et al. (2010)), the same is not true of the 2007-13 period. Looking at the yearly cross-section of GDP vs forcing (or assignment) variable, we see that the 2000-06 negative correlation pattern persists through 2007, starts shifting towards no correlation during 2008-09 as most regions in the Eurozone head towards negative growth territory, and is inverted in 2010 and 2011, as regions in Greece, Portugal and Spain remain at negative growth rates (trapped at the epicenter of the then emerging sovereign debt crisis), while other countries start to recover from the 2008 recession. In other words, there were asymmetric macroeconomic shocks at the country level affecting these regions over time which blur the normally observed positive correlation between the forcing variable and GDP growth\textsuperscript{22}. Furthermore, some of the reasons related to the particular interference of the recent financial and sovereign debt crisis with the allocation mechanisms of these transfers may also contribute to explain the unusual results. This contrasts with the stronger-in-recession measured multipliers in the panel IV estimation core section of this paper using year-on-year changes in expenditures as the fiscal shock of interest, in line with the cross-country findings of Auerbach and Gorodnichenko (2012).

It is worthwhile noting that, in contrast to the earlier panel IV, the coefficient estimates on Table .15 cannot be directly interpreted as fiscal multipliers. Rather, they reflect an average response over the medium-run (the length of a programming period, 6-7 years) to ongoing treatment levels. Recall the independent variable of interest in the RD is the level of transfers (as a ratio to population or GDP), rather than a change in levels, or a shock per se whose propagation can be estimated in subsequent years.

\textsuperscript{21}Restricting the analysis as in Imbens and Lemieux (2008) to a narrow band around the threshold (rather than using the entire sample) would eliminate the results presented here, partially due to smaller sample size, but also due to the similarity in outcomes around the threshold evidenced in the graphs above.

\textsuperscript{22}Becker, Egger and von Ehrlich find that correlation for the 1989-1993, 1994-1999 and 2000-06 programming periods, although looking at the fine print, the 1994-99 effect on average GDP growth they measure using RDD is only significant at the 15\% level, and in all cases the coefficient is around 1\% (so that treated regions grow on average 1\% a year more than non-treated ones).
### Table 15: Regression Discontinuity IV (NUTS 2 level), 2000-2011

<table>
<thead>
<tr>
<th></th>
<th>Annual, 2000-06</th>
<th>Annual, 2007-13</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3rd order</td>
<td>5th order</td>
</tr>
<tr>
<td>Annual Expenditure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>per GDP, 2000-06</td>
<td>2.655**</td>
<td>2.750**</td>
</tr>
<tr>
<td></td>
<td>(1.117)</td>
<td>(1.139)</td>
</tr>
<tr>
<td>Annual Expenditure</td>
<td></td>
<td>0.350*</td>
</tr>
<tr>
<td>per GDP, 2007-13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>1610</td>
<td>1610</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

Annual specifications include year and country fixed effects.
Clustered s.e.s at NUTS 2 level.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Bibliography


Baltagi, Badi, Dong Li, and Qi Li, “Transaction tax and stock market behavior: evidence from an emerging market,” Empirical Economics, June 2006, 31 (2), 393–408.


BIBLIOGRAPHY


—, “TOBIN TAX - Per le operazioni su derivati fino a 200 euro di prelievo,” October 2012.


Thissen, Mark, Frank van Oort, and Dario Diodato, “Integration and Convergence in Regional Europe: European Regional Trade Flows from 2000 to 2010,” ERSA conference papers, European Regional Science Association 2013.


