Investigating the efficiency of financial stock markets with high frequency data

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"The impact of arbitrage on market liquidity", WP 2017

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  - then "with arbitrage present, the adverse selection costs of domestic dealers increase, so that ... liquidity falls" [Domowitz, Glen, and Madhavan (1998)]
- Impact of arbitrage on liquidity depends on reasons why arbitrage opportunities arise

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  - which would improve liquidity contemporaneous [Chordia, Roll, Subrahmanyam (2002)]

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- Part 2: How does arbitrage affect market liquidity?
- for example, if arbitrage opportunities arise because of demand pressure arbitrageurs might trade against net market order imbalance:
  - which would improve liquidity contemporaneous [Chordia, Roll, Subrahmanyam (2002)]
  - and improve future liquidity [O'Hara and Oldfield (1986) and Comerton-Forde, Hendershott, Jones, Moulton, Seasholes (2010)]

Why care?

- Liquidity and efficiency are crucial for the well functioning of financial markets. Deviations from the law of one price are inefficiencies.

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- limits-of-arbitrage:

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- here: arbitrage activity decreases $\Longrightarrow$ liquidity decreases

for example, several frictions affect arbitrage activity

- Short sell constrains; Transaction tax (2018, in the EU); Margin requirements

Do these frictions only harm the efficiency of the market or also its liquidity?

The setting: Data (American Depositary Receipts)

- American Depositary Receipts (ADRs) which are cross-listed securities, and should trade at the same price as home market stock, because
  - give same cash flow as home market stock and can be converted to each other, which minimizes risk in arbitrage
- this makes ADR especially suitable to study arbitrage [Gagnon and Karolyi (2010)]
- Standard sources to create sample: Datastream, adrbnymellon.com and adr.db.com
- 5 different home markets, NYSE and Forex (72 stock pairs)

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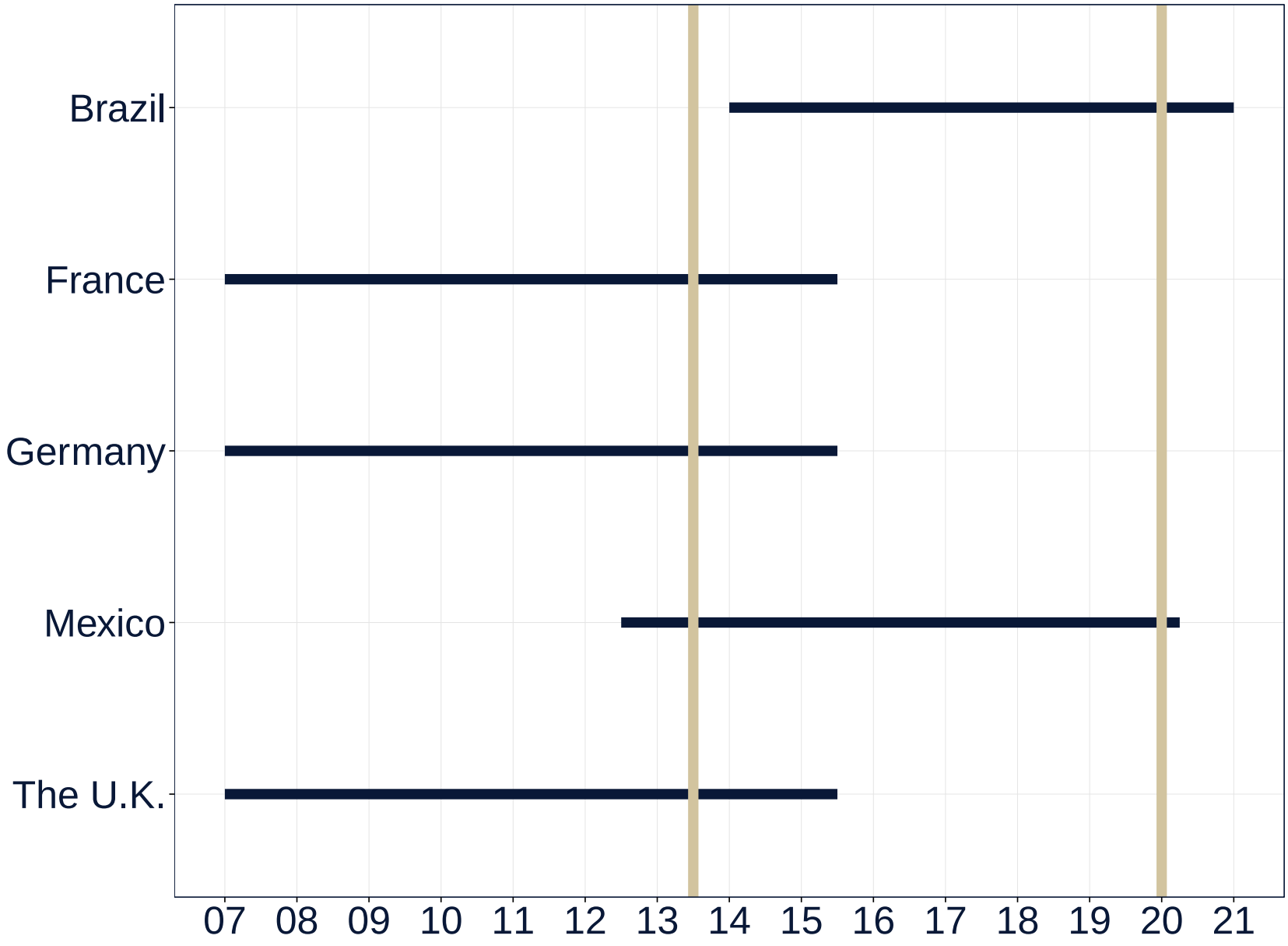
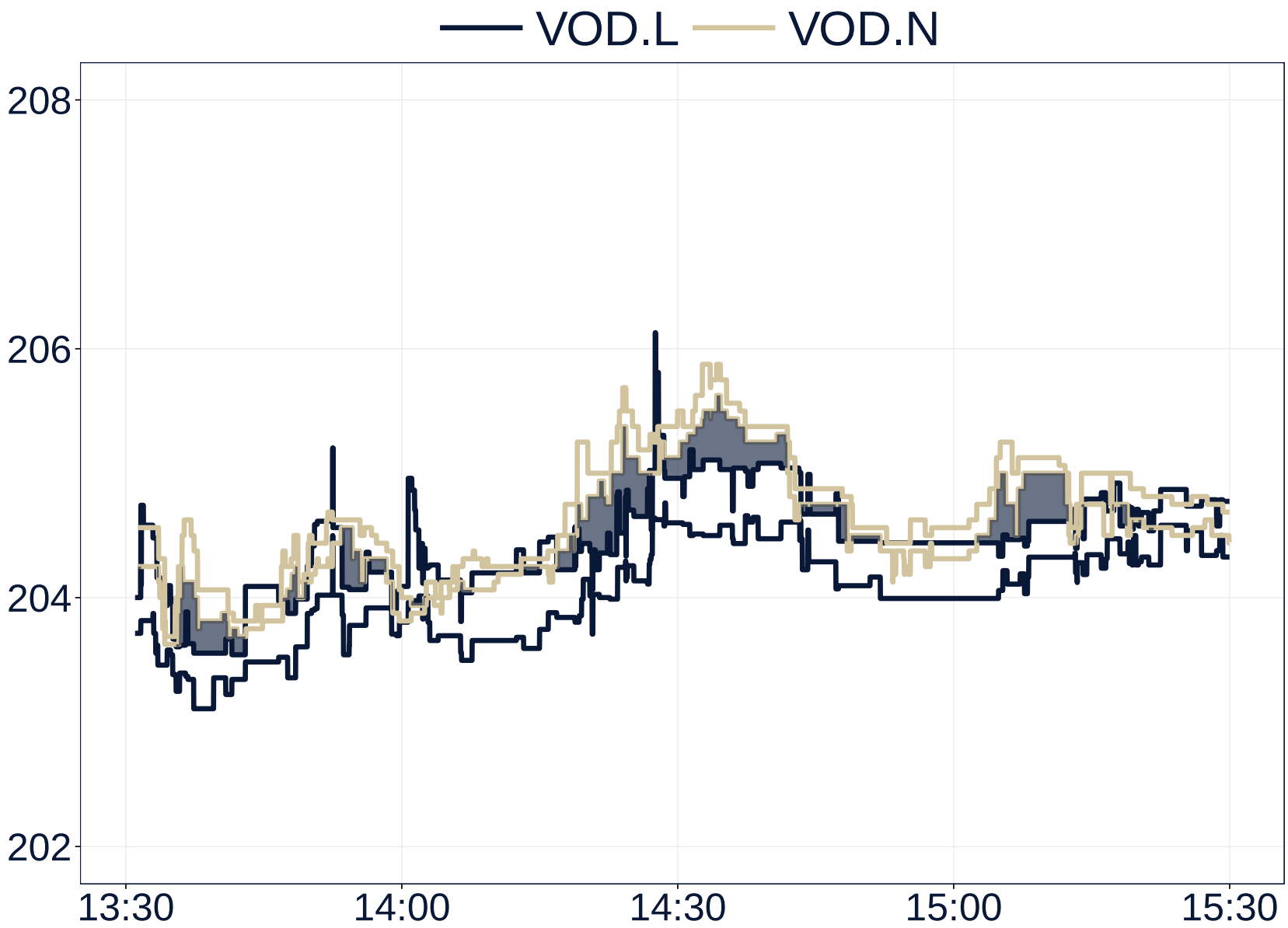
- Standard sources to create sample: Datastream, adrbnymellon.com and adr.db.com
- 5 different home markets, NYSE and Forex (72 stock pairs)
- Tick-by-tick data from 1996 to 2013 on (almost 9 billion) quotes and (almost 1 billion) trades: TRTH

The setting: The clock (in UTC) 2008-10-15



The mechanics of arbitrage in the ADR market



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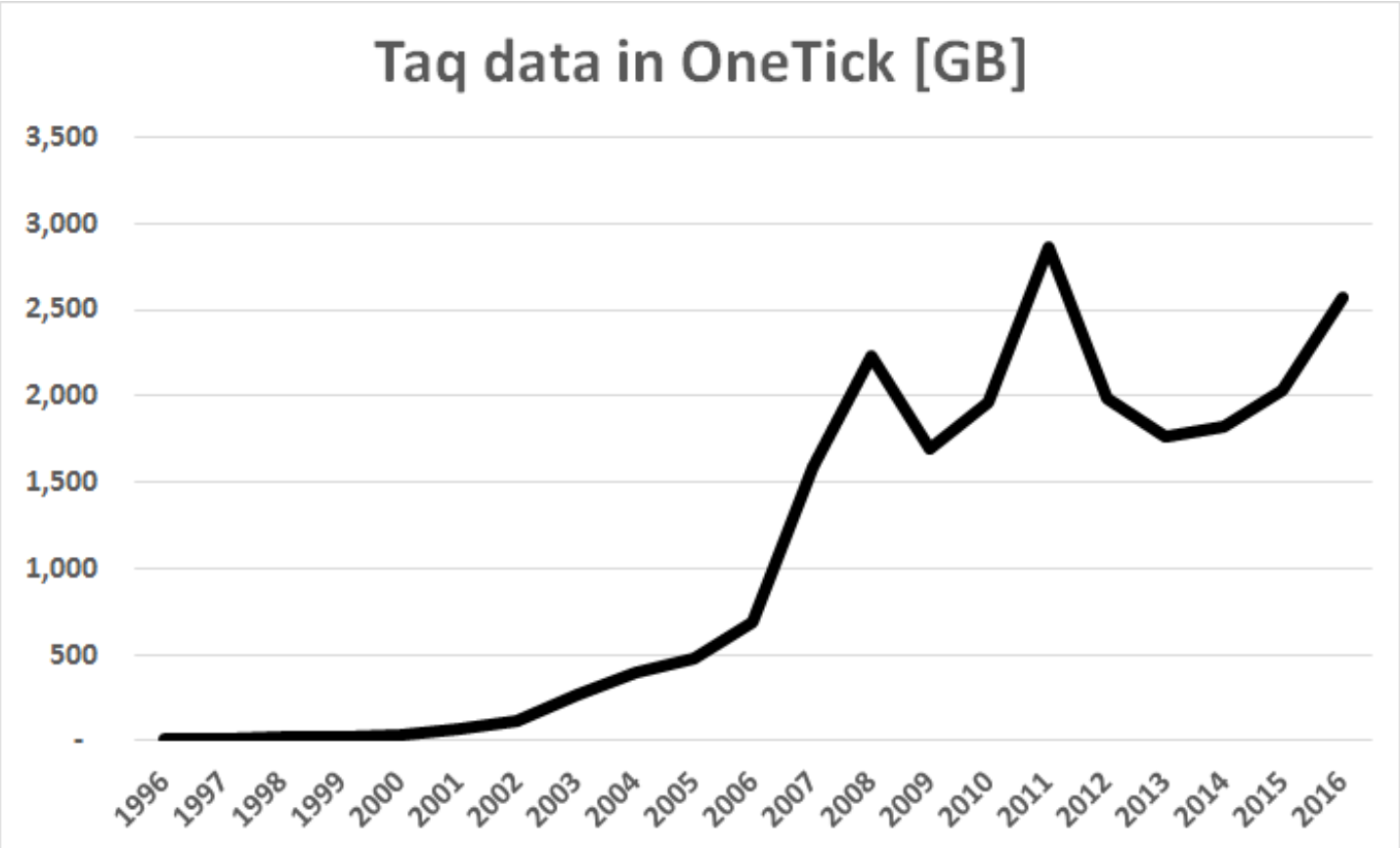
US tick-by-tick data (TAQ)



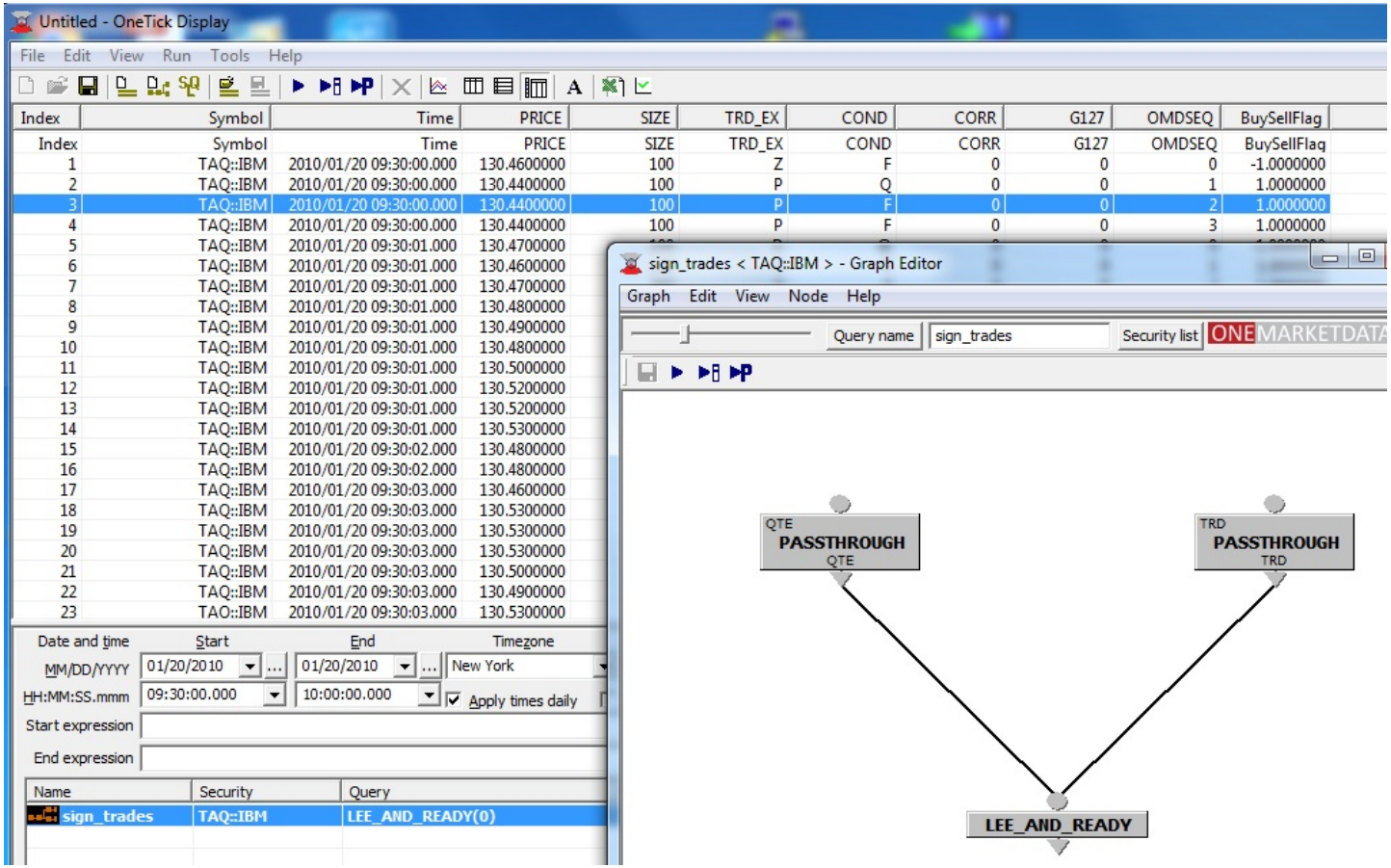
My first attempt: Mysql framework

- I started writing my stored procedure:
  - get_ohlc_for(ticker, between, bucket)
- when I coded:

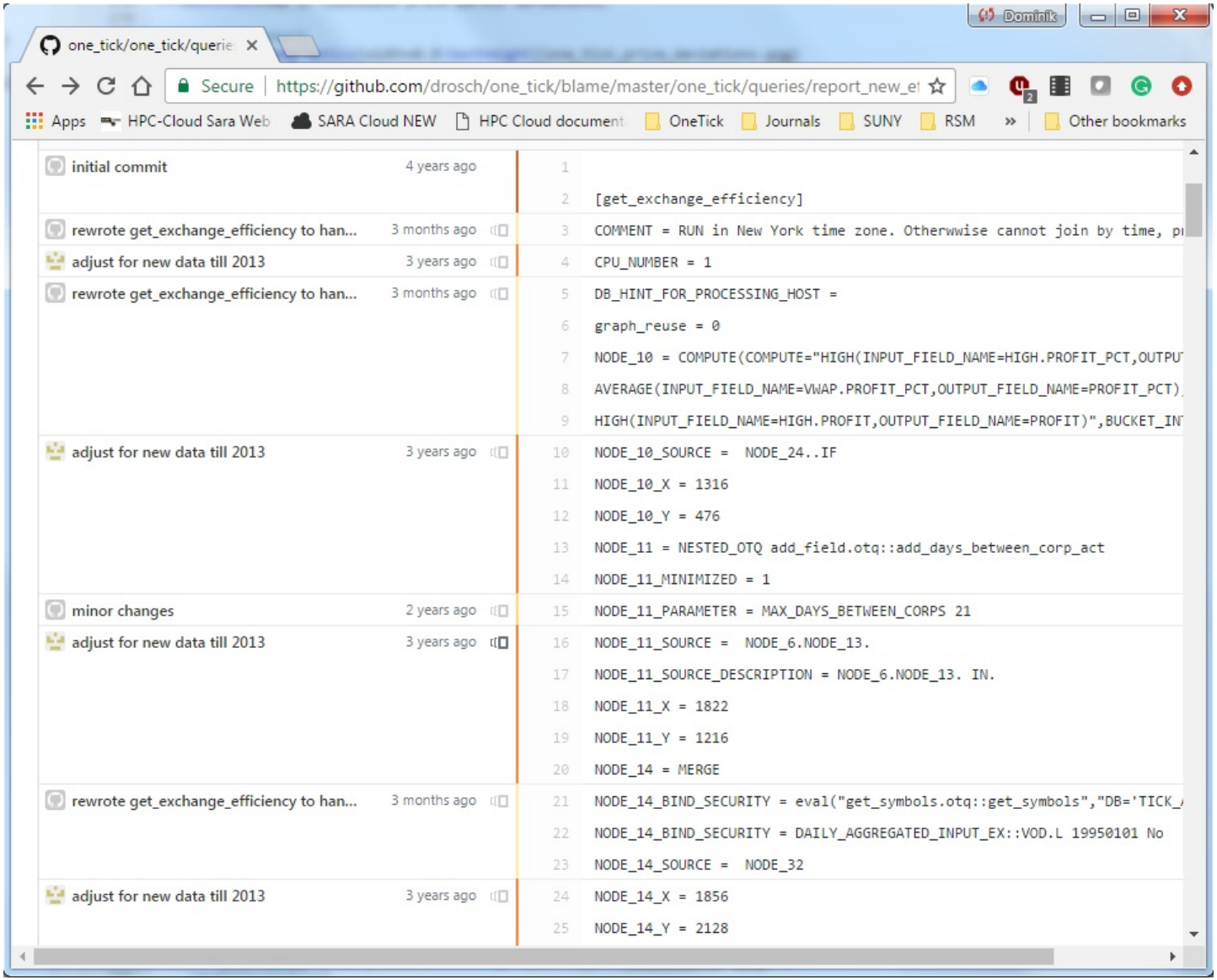
```
SUBSTRING_INDEX(
        MAX(CONCAT(time, '_', price)), '_', -1
) AS `close`
```

- I realized MySQL might not be the best DB for financial data.

My second attempt: OneTick framework



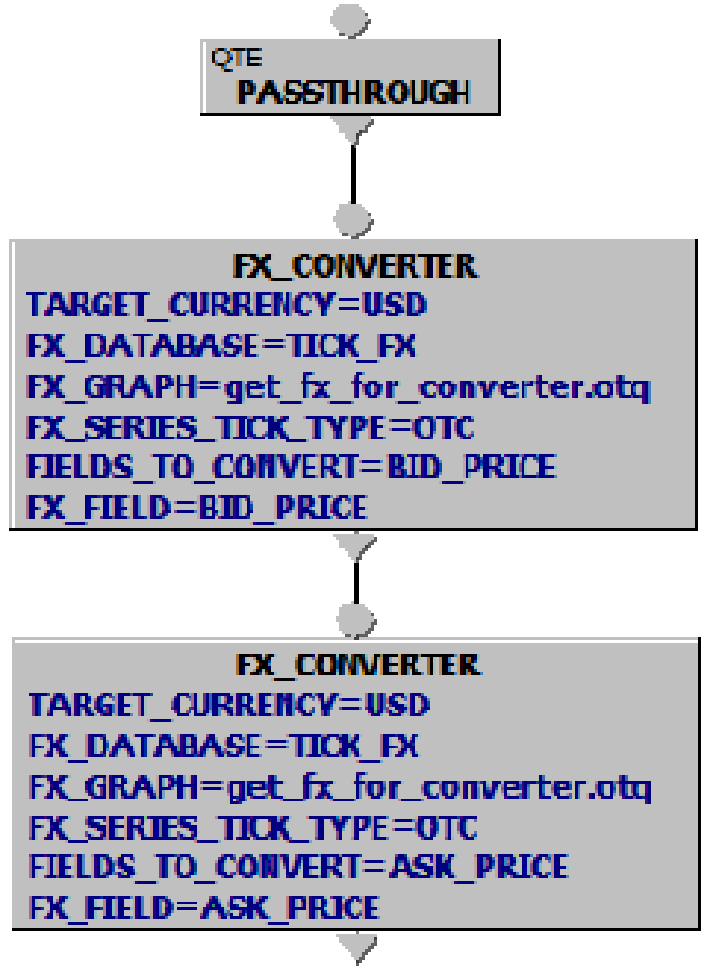
OneTick "code"



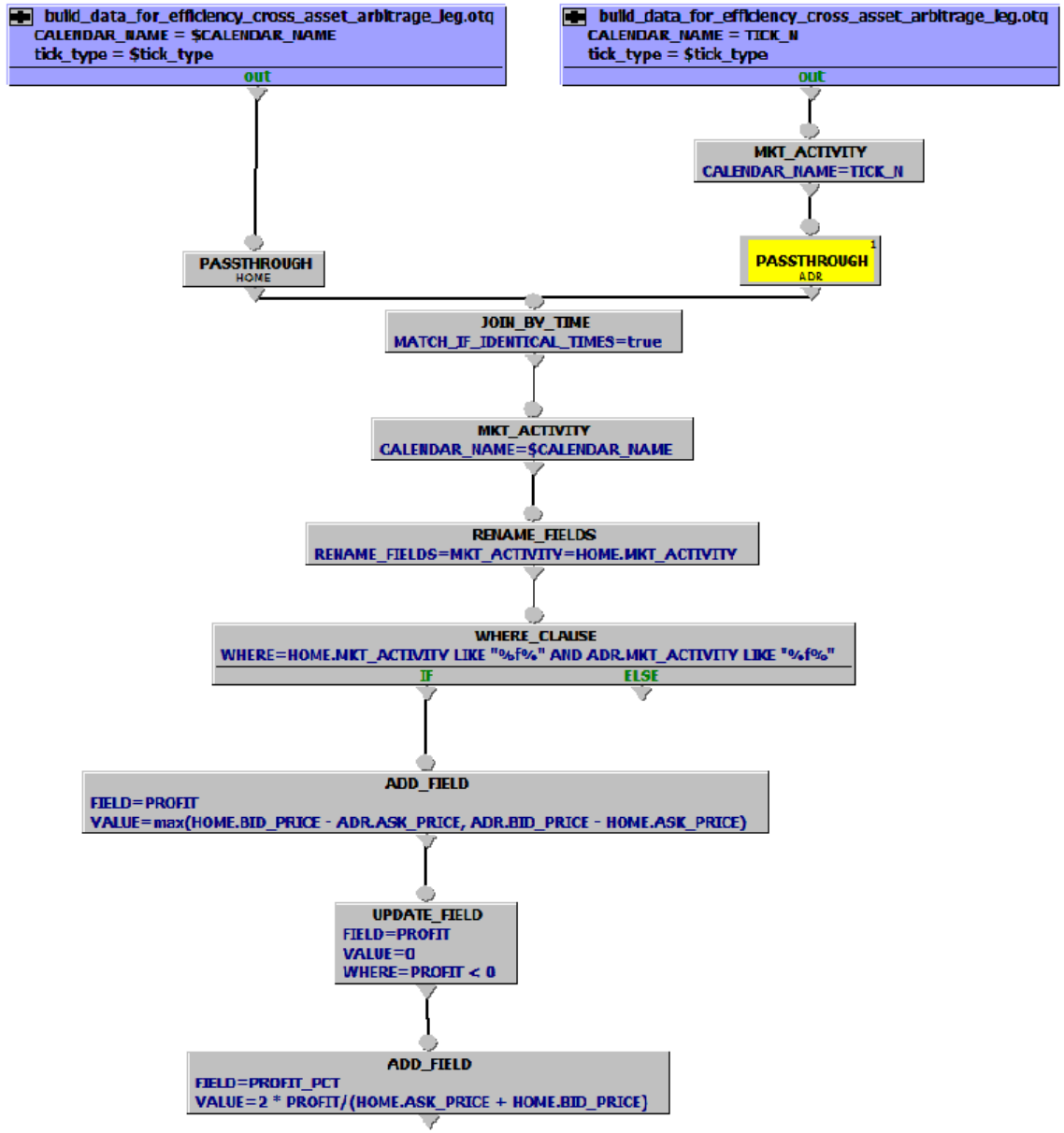
Step 0: Setting up reference data

- Exchange trading times (e.g., LSE: 08:00-16:30 GMT)
- Price adjustments (e.g., VOD.L in pence)
- Price currency (e.g., VOD.L in GBP)
- Symbology mappings
- Corporate actions

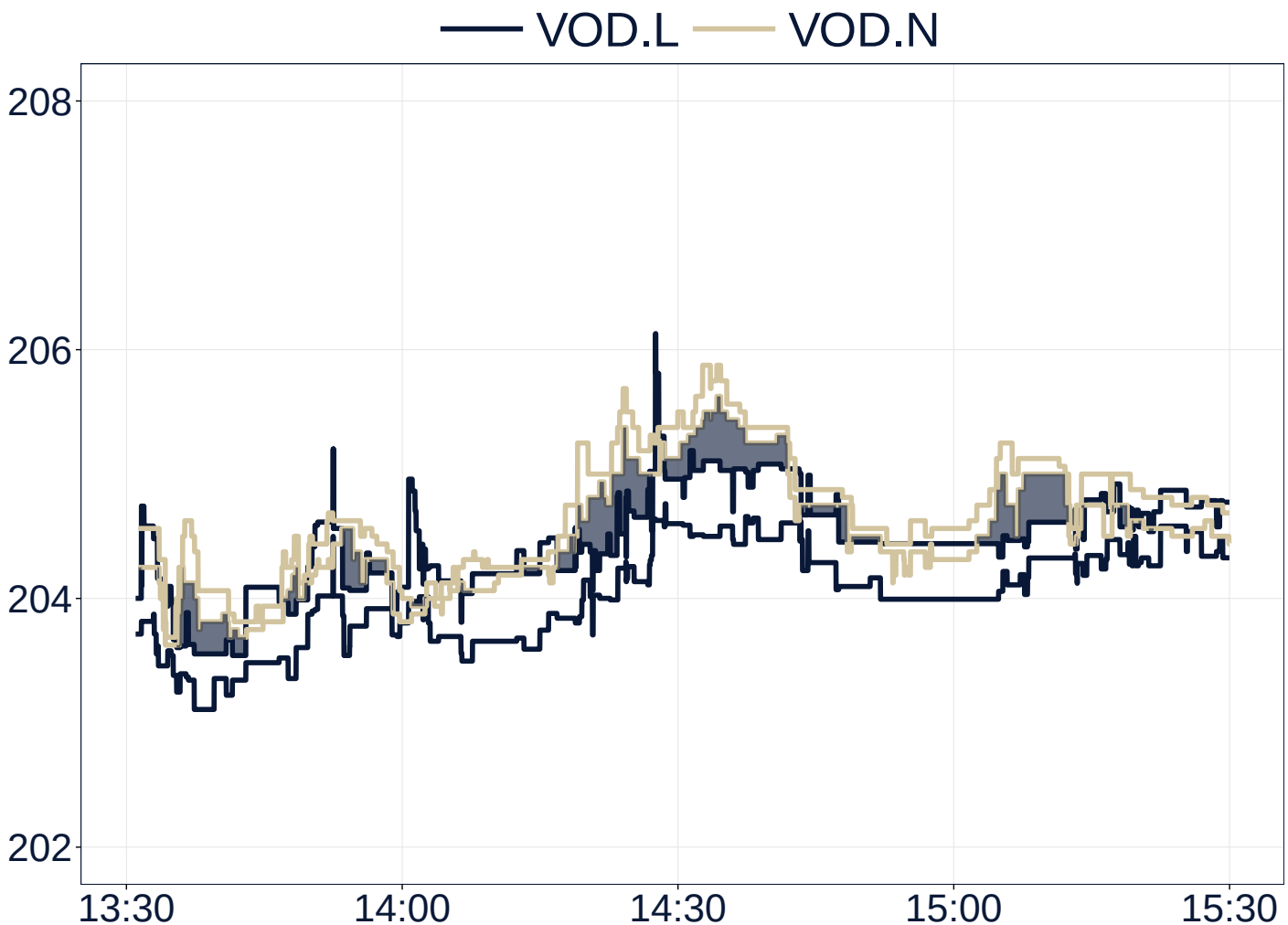
Step 1: Convert prices into common currency



Step 2: Calculate price parity deviations



Market (in)efficiency: deviations from the fair price



Step 3 Run on server (using GNU Parallel)

```
database = ${1}
query    = ${2}

for date in dates.txt ; do
    sem -k --id exp -P ot.cpus
        export.pl ${database} ${date} ${query}
done

sem --wait --id exp
```

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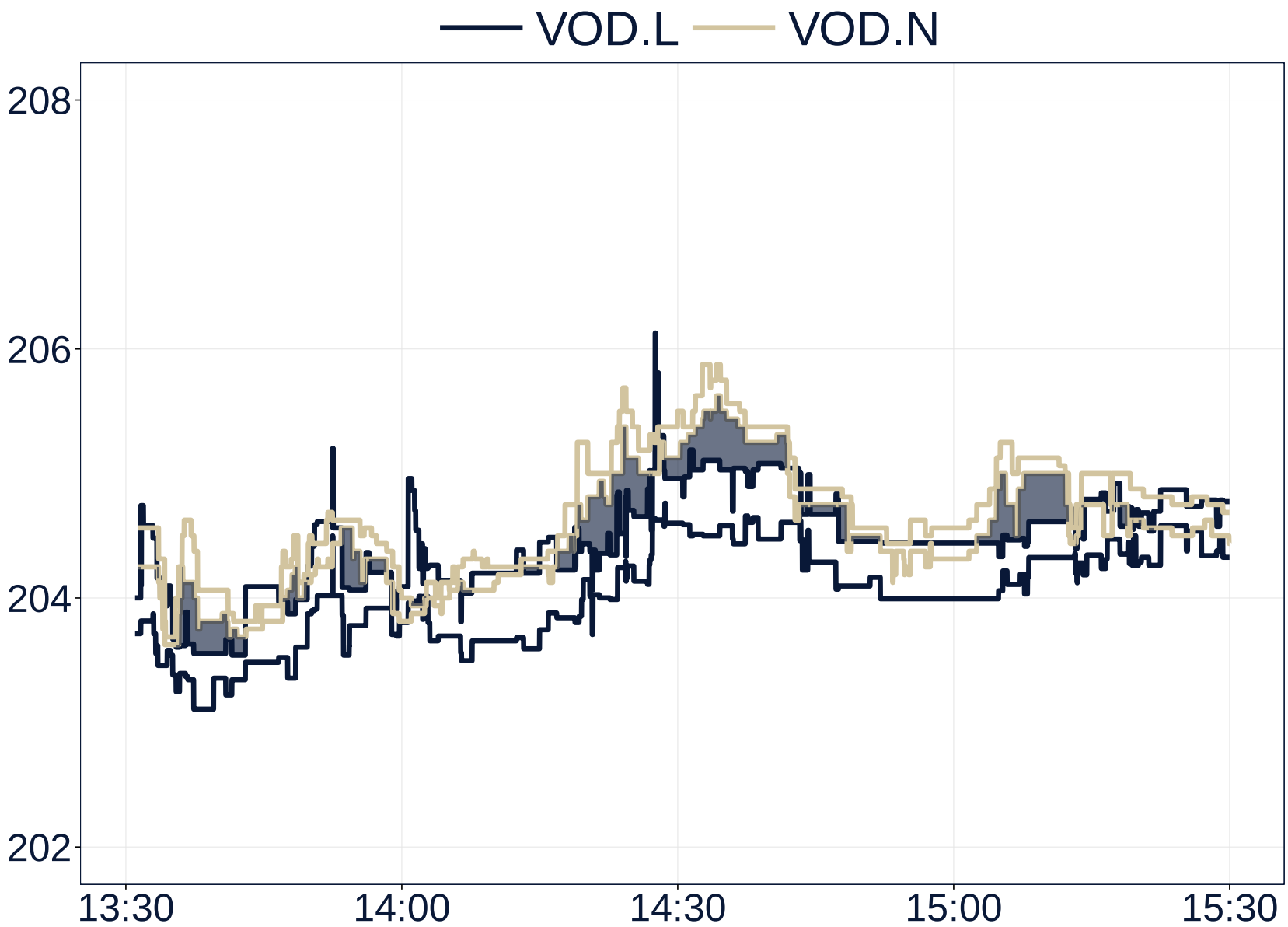
Example Vodafone on 1999-06-15



How do price deviations arise? (part of Table 2)

Following Schultz and Shive (2010)

	# [MM]	%price pressure	*%Home*	*%Host*	*%Both*	*%Forex*
Home	3.3					
Host	4.2					
Both	2.1					
Forex	1.8					

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Following Schultz and Shive (2010)

	# [MM]	%price pressure	*%Home*	*%Host*	*%Both*	*%Forex*
Home	3.74	0.70***	0.45	0.27	0.17	0.11
Host	4.64	0.78***	0.19	0.52	0.17	0.11
Both	2.29		0.24	0.32	0.36	0.09
Forex	1.95		0.20	0.26	0.12	0.43

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Two main challenges:

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- start with Fama (1991): a market is efficient, if "prices reflect information to the point where the marginal benefits of acting ... do not exceed the marginal costs"
- Limits-of-arbitrage tells us what these costs are: e.g. risk, illiquidity, and capital constrains

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- e.g., price deviations are "a symptom of a market in severe shortage of arbitrage capital" (Hu, Pan, Wang 2013)

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- e.g., price deviations are "a symptom of a market in severe shortage of arbitrage capital" (Hu, Pan, Wang 2013)
- thus price deviations are a proxy for the impediments to arbitrage

The setting: Daily proxies

For impediments to arbitrage:

- $INARB_d$: seconds it takes for a price deviation to vanish
- ΔQTE_d: difference in best bid and best ask price across the ADR and home market share
- ΔTRD_d: difference in prices of simultaneous trades

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For market quality:

- **quoted spreads**

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For market quality:

- **quoted spreads**
- effective spreads (in paper)

Two main challenges:

2) How to address reverse causality between illiquidity and impediments to arbitrage?

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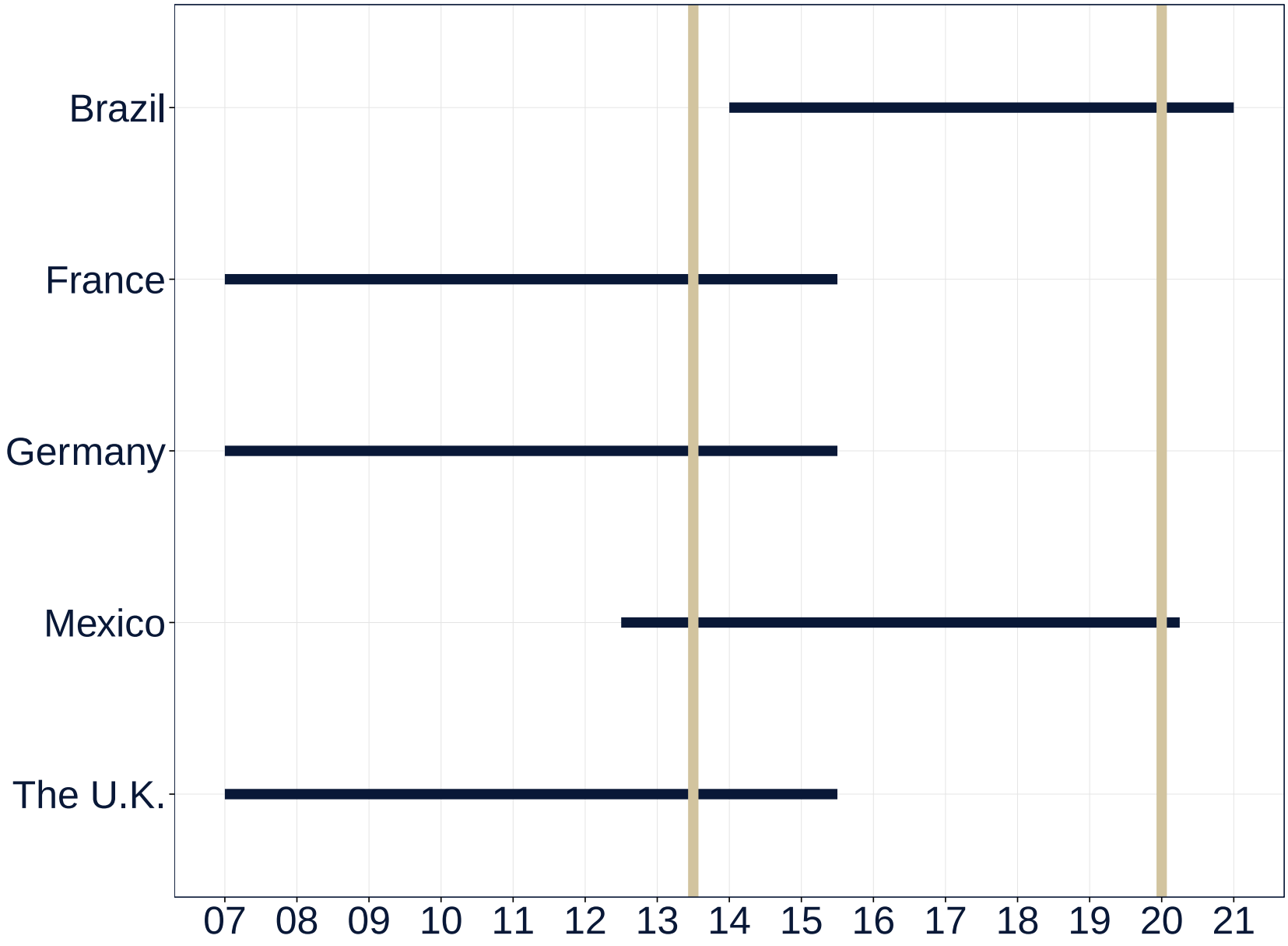
- Control directly for other important variables that explain illiquidity, e.g. volatility (in paper)
- Use a panel regression to control for time- and stock-invariant heterogeneity (in paper)
- Use a difference approach...

Difference in illiquidity during and outside overlapping trading times



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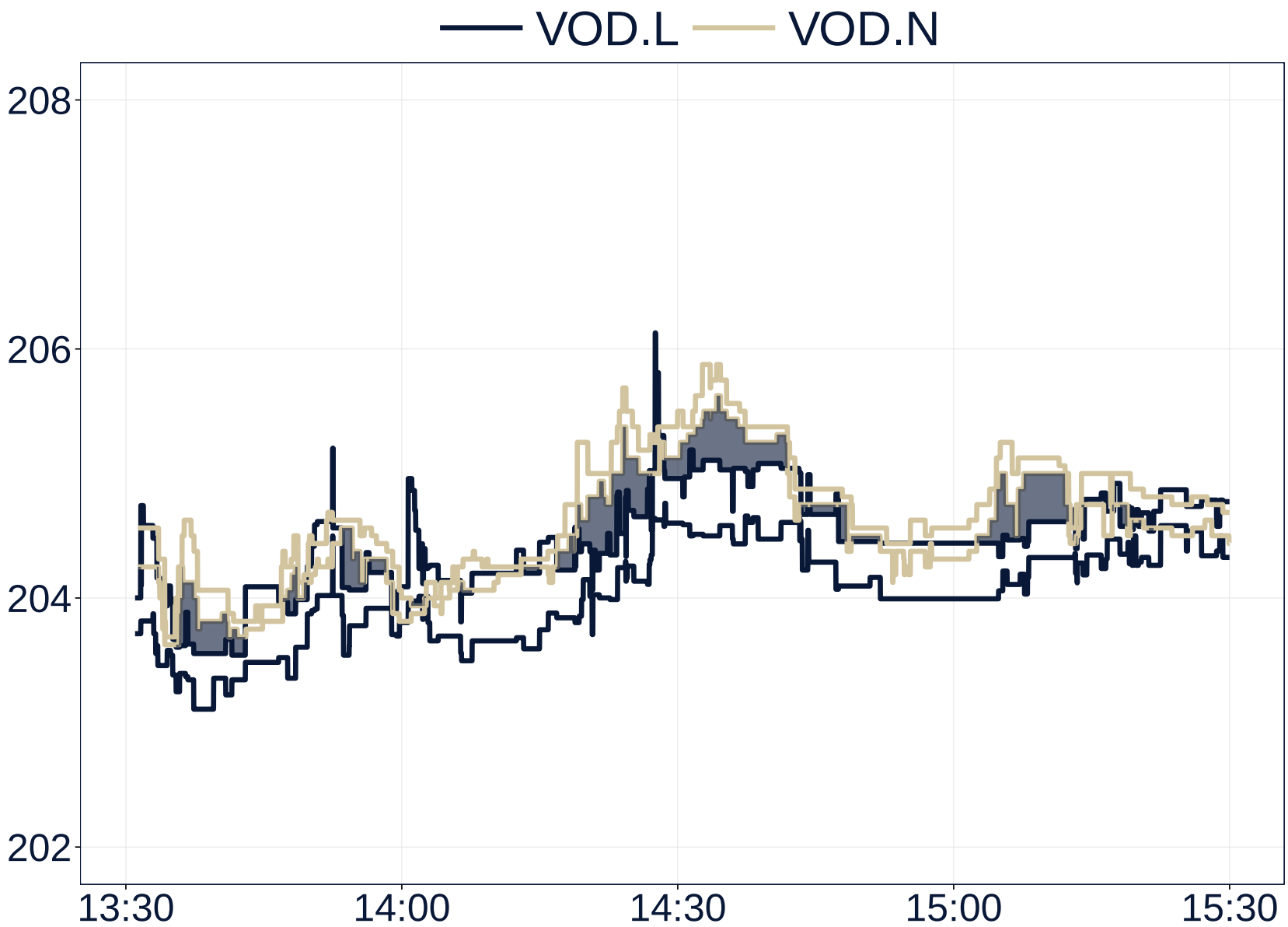

Summary statistics (part of Table 1)

	avg	stddev	min	median	max
$avg(\Delta TRD)$	0.45	0.33	0.06	0.40	2.41
$avg(\Delta QTE)$	0.25	0.20	0.00	0.23	0.88
$max(\Delta QTE)$	0.73	0.46	0.14	0.66	3.07
duration [sec]	414	429	4	315	2,479

Summary statistics (part of Table 1)

	avg	stddev	min	median	max
Panel A: Price deviations outside days between corporate actions:					
$avg(\Delta TRD)$	0.45	0.33	0.06	0.40	2.41
$avg(\Delta QTE)$	0.25	0.20	0.00	0.23	0.88
$max(\Delta QTE)$	0.73	0.46	0.14	0.66	3.07
duration [sec]	414	429	4	315	2,479
Panel B: Price deviations during days between corporate actions:					
# days	18	21	0	12	102
$avg(\Delta QTE)$	1.46	2.57	0.07	0.85	13.10
$avg(\Delta AQTE)$	0.62	0.84	0.00	0.30	4.82
$max(\Delta QTE)$	2.48	2.55	0.25	2.00	13.80
$max(\Delta AQTE)$	1.27	0.98	0.14	0.89	5.17

How does arbitrage affect liquidity: Panel instrumental variable regression. (part of Table 6)

$$PQSPR_{i,d} = \alpha + \beta \times \Delta\widehat{Price}_{i,d} + \boldsymbol{\beta} \times \boldsymbol{Controls}_{i,d} + \epsilon_{i,d}$$

	$Host_{i,d}$	$Host_{i,d}$	$Host_{i,d}$	$Host_{i,d}$	$Host_{i,d}$	$Home_{i,d}$	$Home_{i,d}$	$Home_{i,d}$	$Home_{i,d}$	$Home_{i,d}$
$\widehat{INARB_0}$	0.01**					0.01*				
	(0.03)					(0.06)				
$\widehat{avg(\Delta QTE_d)}$	0.02**					0.02**				
	(0.02)					(0.05)				
$\widehat{max(\Delta QTE_d)}$		0.01**					0.01*			
		(0.02)					(0.05)			
$\widehat{max(\Delta AQTE_d)}$			0.04*					0.03		
			(0.09)					(0.11)		
$\widehat{avg(\Delta TRD_d)}$				0.02**					0.01**	
				(0.03)					(0.05)	
Controls				Yes						
StockFE				Yes						
DayFE				Yes						
StockDays				136,363						

How does arbitrage affect liquidity: Panel instrumental variable regression.

(part of Table 6)

$$\delta PQSPR_{i,d} = \alpha + \beta \times \Delta\widehat{Price}_{i,d} + \boldsymbol{\beta} \times \boldsymbol{Controls}_{i,d} + \epsilon_{i,d}$$

	$Host_{i,d}$	$Host_{i,d}$	$Host_{i,d}$	$Host_{i,d}$	$Host_{i,d}$	$Home_{i,d}$	$Home_{i,d}$	$Home_{i,d}$	$Home_{i,d}$	$Home_{i,d}$
$\widehat{INARB}_{i,d}$	0.008***				0.010*					
	(0.00)				(0.07)					
$\widehat{avg(\Delta QTE_{i,d})}$	0.018***					0.023*				
	(0.00)					(0.09)				
$\widehat{max(\Delta QTE_{i,d})}$		0.013***					0.017*			
		(0.00)					(0.07)			
$\widehat{max(\Delta AQTE_{i,d})}$			0.060***					0.075*		
			(0.00)					(0.07)		
$\widehat{avg(\Delta TRD_{i,d})}$				0.017***					0.022*	
				(0.00)					(0.09)	
Controls				Yes						
StockFE				Yes						
DayFE				Yes						
StockDays				136,363						

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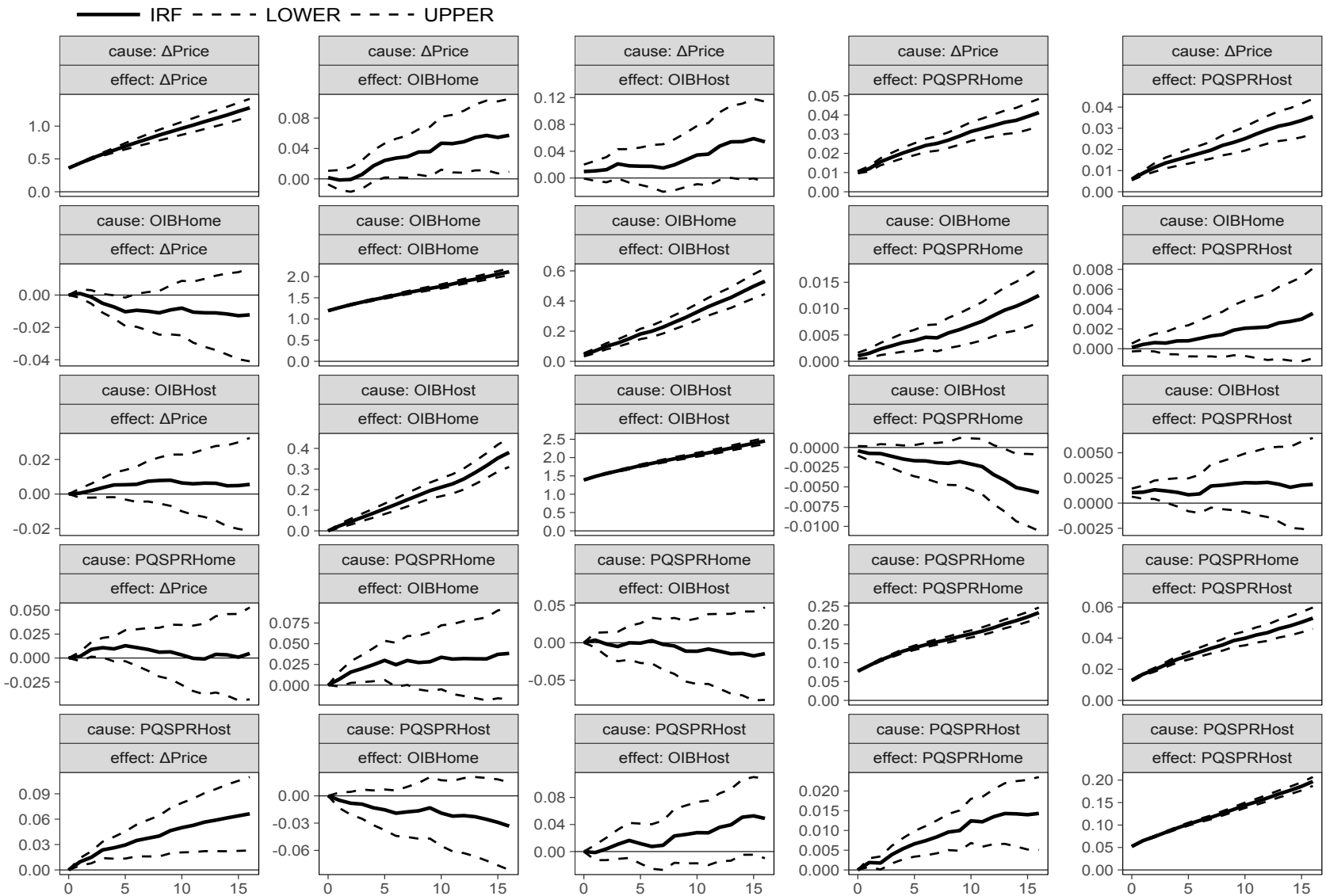
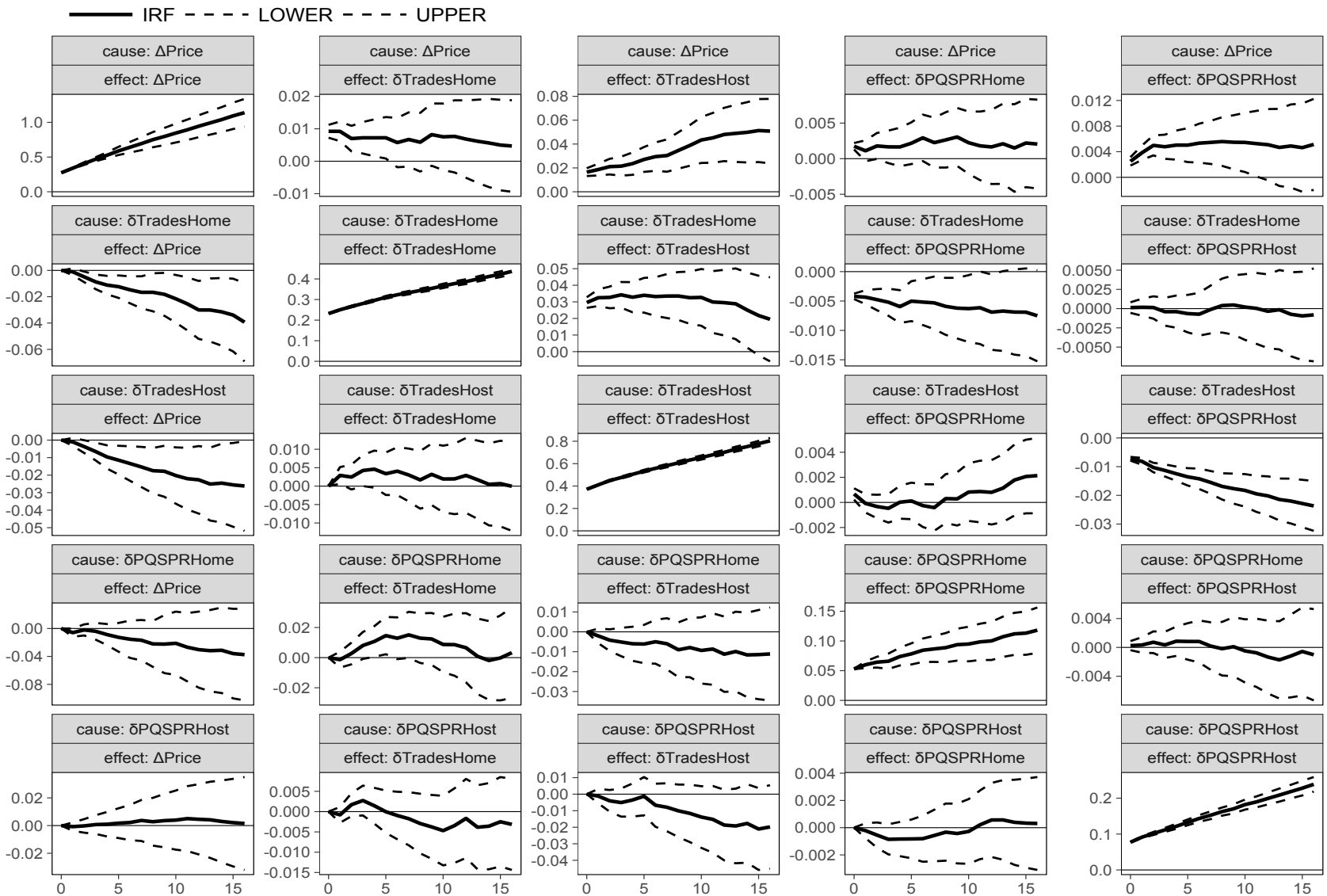
How does arbitrage affect liquidity: Impulse response functions (Figure 1)



How does arbitrage affect liquidity: Impulse response functions (Figure 3)



The impact of transaction taxes on impediments to arbitrage. (Table 8)

$$LHS_{i,d} = FE + \beta_0 \times FFTT_{i,d} + \beta_1 \times AfterFFTT_{home,i,d} + \beta_2 \times AfterFFTT_{host,i}$$

	$INARB_{i,d}$	$a(\Delta Q_{i,d})$	$m(\Delta Q_{i,d})$	$m(\Delta AQ_{i,d})$	$a(\Delta T_{i,d})$
$FFTT_{i,d}$	-0.726	-0.069	0.274	-0.061	0.083
	(0.48)	(0.33)	(0.30)	(0.39)	(0.53)
$AfterFFTT_{Home,i,d}$	1.299***	0.089***	0.128***	0.091***	0.125***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$AfterFFTT_{Host,i,d}$	0.415	0.054	0.031	0.007	0.049
	(0.49)	(0.48)	(0.74)	(0.90)	(0.55)
StockFE			Yes		
DayFE			Yes		
StockDays			17,358		

The impact of transaction taxes on illiquidity. (Table 8)

$$LHS_{i,d} = FE + \beta_0 \times FFTT_{i,d} + \beta_1 \times AfterFFTT_{home,i,d} + \beta_2 \times AfterFFTT_{host,i}$$

	Panel B: *PQSPR*		Panel C: *PESPR*		Panel D: δ*PQSPR*	
	$Host_{i,d}$	$Home_{i,d}$	$Host_{i,d}$	$Home_{i,d}$	$Host_{i,d}$	$Home_{i,d}$
$FFTT_{i,d}$	0.066	0.012	0.023	0.011	0.044**	0.001
	(0.27)	(0.12)	(0.39)	(0.26)	(0.04)	(0.84)
$AfterFFTT_{Home,i,d}$	0.046***	0.005**	0.037*	0.005*	-0.011	0.000
	(0.00)	(0.04)	(0.07)	(0.09)	(0.39)	(0.87)
$AfterFFTT_{Host,i,d}$	0.013	0.001	-0.021	-0.001	-0.007	0.002
	(0.18)	(0.62)	(0.27)	(0.63)	(0.16)	(0.11)
StockFE			Yes			
DayFE			Yes			
StockDays			136,363			

Summary

- Arbitrage opportunities mainly arise due to demand pressure
- An increase in the impediments to arbitrage deteriorates liquidity
  - contemporaneously
  - and over the coming days
- In particular, transaction taxes lower liquidity and thereby increase the cost of capital for firms