

Financial Market Frictions and Learning from the Stock Price

Lets “Pay attention to the plumbing” (Levitt 2003)

Dominik Rösch

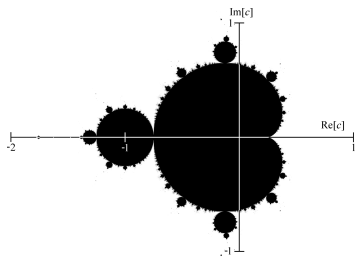
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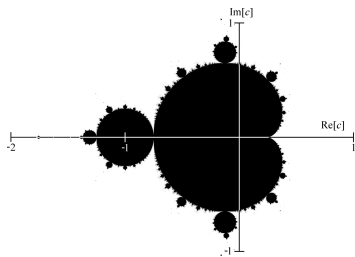
February 13, 2020

This work is supported in part by NSF ACI-1541215.

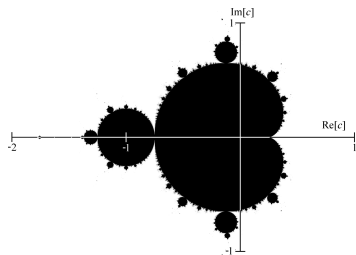
Mandelbrot Set



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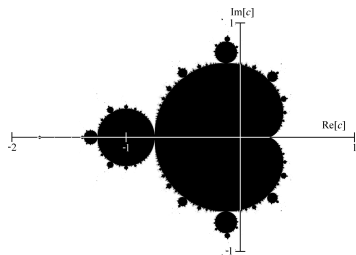
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coloured by how fast $c \notin C =$
 $(\mathbb{R}; \mathbb{R})$ converges to infinity in:

$$z_{n+1} = z_n^2 + c; \text{ with } z_0 = 0$$

Mandelbrot Set



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“Can there be a more striking demonstration of the enormous complexity hidden in the simplest laws?” (Peitgen, Richter 1986)

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 - | Companies often have different share classes, such companies are often dropped from empirical analysis.
- | Prices are (almost) meaningless as they are under the control of the company
- | Prices are often more understood as ratios, e.g., price to earnings, price to book, or just returns.

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- | Starting with USD 1, after less than 30 years you are a billionaire!
- | Or are you? Actually, in the long-term you lose, the expected continuously compounded return is negative!
- | Empirically, should you use simple or log-returns? What about dividends? (convention: assumed re-invested, except in special papers)

In our case Stock Price: Tobins Q (Corporate Finance)

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- | Actually, $Q = (mktcap = 1000 + atq - bvse) / atq$ with $mktcap = jPrice_j \cdot shrout$
- | because of scaling and in CRSP *Price* can be negative

Financial Market Frictions (Market Microstructure)

- | Illiquidity
 - | Quoted Spreads
 - | Effective Spreads
- | Inefficiency
 - | OIB Predictability
 - | Variance ratio
 - | Hasbrouck
 - | Put-call parity
- | Not necessarily, Inefficiency = Illiquidity.

“Financial Market Frictions and Learning from the Stock Price”

- | “Learning”: Investment-Sensitivity to Q (ISQ), Q -Theory

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$$| \text{Inv}_{i;q} = \alpha_{0;q} + \beta_{1;q} \text{Fric}_{i;q} + \gamma_{1;q} Q_{i;q} + \beta_{2;q} \text{Fric}_{i;q} + \gamma_{3;q} Q_{i;q} + \sum_q \alpha_q \text{Contr}_{i;q} + \epsilon_{i;q}$$

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| Investment is measured, e.g., as CAPX which is reported as a running sum within each fiscal year.

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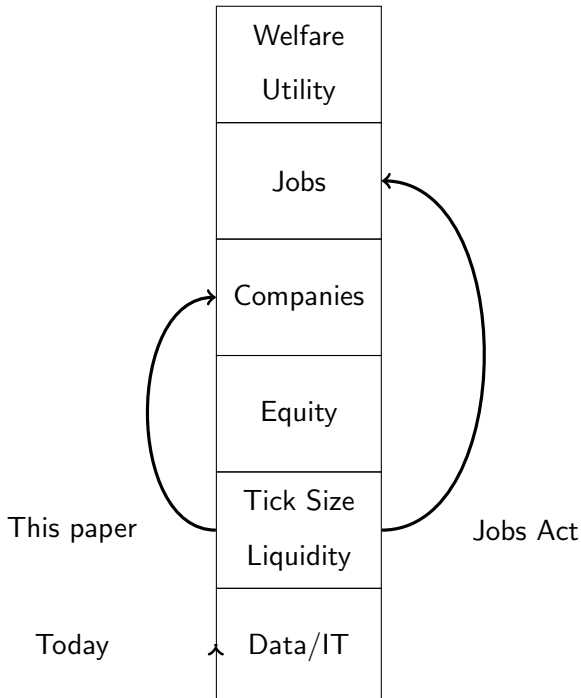
- | Investment is measured, e.g., as CAPX which is reported as a running sum within each fiscal year.

- | Do frictions increase or decrease ISQ ($\beta_{1;q}$)

- | We find: $\beta_{1;q} > 0$, ISQ increases with frictions, ISQ is lower for more liquid stocks (because of noise trading)

- | “[w]hat’s needed for a liquid market causes prices to be less efficient” (Black, 1986, p. 532).

- | Normally, now argue that this relation is causal.



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- | 2kb: 2922.07 is an average of across around 500 prices
- | 20kb: Each stock is priced on around 10 venues.
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- | if you compress the data you need around 10GB/day.

US tick-by-tick data (TAQ)

- | Data contains more than just prices, such as sizes, and other identifiers. Data does not contain depth, just the best available buy and sell prices per venue.

My first attempt: Mysql framework

- | I started writing my stored procedure:
 - | `get_ohlcv_for(ticker, between, bucket)`

- | when I coded:

```
SUBSTRINGINDEX(
```

```
    MAX(CONCAT(time, '-', price)), '-', -1
```

```
) AS `close`
```

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

My second attempt: OneTick framework

Step 0: Setting up reference data

- | Exchange trading times (e.g., NYSE: 09:00-16:30)
- | Primary Exchange (e.g., IBM is NYSE)
- | Symbology mappings (PERMNO to TICKER, e.g. Citigroup)
 - | 70519||19861029000000|19890119000000|CCC|
 - | 70519||19890120000000|19931231000000|PA|
 - | 70519||19940103000000|19981007000000|TRV|
 - | 70519||19981008000000|19981203000000|CCI|
 - | 70519||19981204000000|20161230000000|C|
- | Corporate actions (stock splits, dividends)

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- | Corporate actions (stock splits, dividends)
- | After REF_DATA and importing TAQ: Lets compute effective spreads...

Effective spreads: Data Processing

- | $ESPR_{i;t} = 2 \cdot \text{sign}_{i;t} \cdot (\text{TRD}_{i;t} - \text{MID}_{i;t})$
- | Need TRD prices and midpoint prices prevailing $\text{TRD}_{i;t}$, $\text{MID}_{i;t}$

Effective spreads: Data Processing

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- | Need TRD prices and midpoint prices prevailing $\text{TRD}_{i;t}, \text{MID}_{i;t}$
- | "For data before 1996, we delay quotes by 5 seconds following Lee and Ready (1991)."
- | "We use monthly TAQ data from 1993 to 2014, with trades and quotes timestamped by the second, and daily TAQ data from 2014 onwards."
- | "We apply the Holden and Jacobsen (2014) interpolated time technique for all data from 1983 to 2014"
- | $\text{sign}_{i;t}$ use Lee and Ready (1991) using NBBO (?), or take absolute values (equivalent?)

Step 1.0: QTE need National Best Bid Offer (NBBO)

- | Each exchange reports prices.
- | Easy for TRD: \sum" them up.
- | Difficult for QTE: at each point in time look at all ASK (BID) across exchanges and take best one, i.e., lowest (highest)
- | This is called National Best Bid and Offer (NBBO)
- | TAQ has a file with NBBO prices, but with errors.
- | Before NBBO, do not ignore 0's, this means orders are cancelled and current exchange doesn't have valid price.

Step 1.0: Compute NBBO

Step 1.0: Compute NBBO, "Limit order book"

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- | construct a virtual order book based on Best Bid Ask quotes from different exchanges.

Step 1.1: MTAQ vs DTAQ: Holden and Jacobsen (2014) interpolated time

- | MTAQ is timestamped at second accuracy, DTAQ at least milliseconds.
- | Imagine one trade with many quotes in second.
- | You want quote prevailing, but which one?

Step 1.1: Compute interpolated time

Step 1.2: Delay quotes

- | Why? TRD and QTE are reported separately. TRD not as important, therefore reported with delay.

Step 1.2: Delay quotes

- | Why? TRD and QTE are reported separately. TRD not as important, therefore reported with delay.
- | Timestamps of both are when published by SIP (Securities Information Processor, see Bartlett and McCrary JFM, 2019)
- | DTAQ provides several timestamps like "Participant Timestamp", "Trade Reporting Facility (TRF) Timestamp" (see NYSE)

Step 2: Compute Effective spreads per trade

Step 3: Aggregate Effective spread per day

Step 3: Aggregate Effective spread per day

- | How to measure effective spreads without trades?
- | How to measure quoted spreads without quotes?
- | Decision to trade/quote are endogenous.

Step 4 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
```

Step 5: Test! TDD, write a test suite.

```
lives_ok {  
  $one_tick->import_csv();  
}  
'can import data into OneTick';
```

```
my $results_summary = {  
  'total_ticks' => 196232,  
};
```

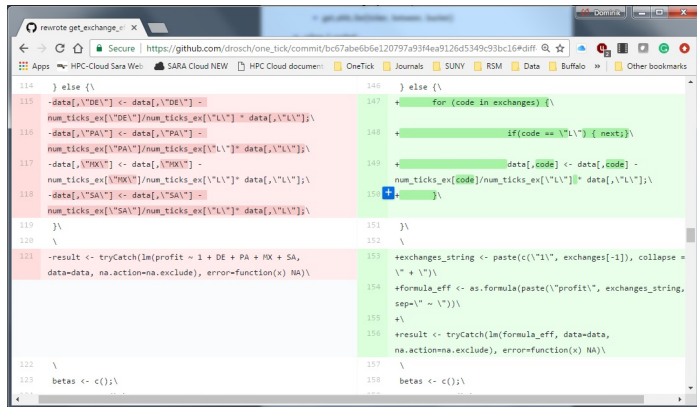
```
Test::More::is_deeply($one_tick->results_summary,  
  $results_summary,  
  'Got summary results as expected'  
);
```

Step 6: Write a paper

- | RStudio (easiest at Vidia CCR or RStudio Cloud) within Rstudio:
 - | Version Control
 - | \File" ! \New Project" ! \Version Control Git"
 - | Use \https" address, better set up \ssh"
 - | Reproducible (R Sweave)
 - | \New File" ! \R Sweave"
 - | Access to Data (ODBC)
 - | \Connections" ! \New Connection" (right)

Step 6.1: How to make sure code is consistent? Version Control!

Step 6.1: How to make sure code is consistent? git diff



```
114 } else {\n115 -data[,\"DE\"] <- data[,\"DE\"] -\n116   num_ticks_ex[,\"DE\"]/num_ticks_ex[,\"L\"] * data[,\"L\"];\n117 -data[,\"PA\"] <- data[,\"PA\"] -\n118   num_ticks_ex[,\"PA\"]/num_ticks_ex[,\"L\"] * data[,\"L\"];\n119 -data[,\"MX\"] <- data[,\"MX\"] -\n120   num_ticks_ex[,\"MX\"]/num_ticks_ex[,\"L\"] * data[,\"L\"];\n121 -data[,\"SA\"] <- data[,\"SA\"] -\n122   num_ticks_ex[,\"SA\"]/num_ticks_ex[,\"L\"] * data[,\"L\"];\n123 }\n\n122 \n123 betas <- c();\n\n146 } else {\n147 +   for (code in exchanges) {\n148 +     if(code == \"L\") { next; }\n149 +     data[,code] <- data[,code] -\n150       num_ticks_ex[,code]/num_ticks_ex[,\"L\"] * data[,\"L\"];\n151 +   }\n152 }\n\n153 +exchanges_string <- paste(c(\"L\", exchanges[-1]), collapse =\n154   \" + \")\n155 +formula_eff <- as.formula(paste(\"profit\", exchanges_string,\n156   sep=\" ~ \"))\n157 \n158 +result <- tryCatch(lm(formula_eff, data=data,\n159   na.action=na.exclude), error=function(x) NA)\n160 \n161 \n162 \n163 \n164 \n165 \n166 \n167 \n168 \n169 \n170 \n171 \n172 \n173 \n174 \n175 \n176 \n177 \n178 \n179 \n180 \n181 \n182 \n183 \n184 \n185 \n186 \n187 \n188 \n189 \n190 \n191 \n192 \n193 \n194 \n195 \n196 \n197 \n198 \n199 \n200 \n201 \n202 \n203 \n204 \n205 \n206 \n207 \n208 \n209 \n210 \n211 \n212 \n213 \n214 \n215 \n216 \n217 \n218 \n219 \n220 \n221 \n222 \n223 \n224 \n225 \n226 \n227 \n228 \n229 \n230 \n231 \n232 \n233 \n234 \n235 \n236 \n237 \n238 \n239 \n240 \n241 \n242 \n243 \n244 \n245 \n246 \n247 \n248 \n249 \n250 \n251 \n252 \n253 \n254 \n255 \n256 \n257 \n258 \n259 \n260 \n261 \n262 \n263 \n264 \n265 \n266 \n267 \n268 \n269 \n270 \n271 \n272 \n273 \n274 \n275 \n276 \n277 \n278 \n279 \n280 \n281 \n282 \n283 \n284 \n285 \n286 \n287 \n288 \n289 \n290 \n291 \n292 \n293 \n294 \n295 \n296 \n297 \n298 \n299 \n300 \n301 \n302 \n303 \n304 \n305 \n306 \n307 \n308 \n309 \n310 \n311 \n312 \n313 \n314 \n315 \n316 \n317 \n318 \n319 \n320 \n321 \n322 \n323 \n324 \n325 \n326 \n327 \n328 \n329 \n330 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\n995 \n996 \n997 \n998 \n999 \n1000
```

Step 6.2: Pull results into favourite statistical software: ODBC

- Regardless which DB, use stored procedures.

```
library("RODBC")
```

```
channel <- odbcConnect("ONETICK_DEFAULT_DSN")
```

```
test <- sqlQuery(channel, "SELECT *
```

```
FROM OTQ_FILES.examples::get_pespr QTE
```

```
WHERE (QTE.TIMESTAMP >= '2004-01-01 00:00:00 GMT
```

```
AND (QTE.TIMESTAMP < '2004-01-03 00:00:00 GMT
```

```
AND (param_assign('query_params', '')=1)"
```

```
)
```

Step 6.3: How to make sure paper is reproducible? RSweave!

- | Embed ODBC / R-code into Latex using RSweave.

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```
\begin{table}[H]
  \caption{\textbf{Caption ...} This table reports
}
  \#Stocks &      Mean  \\\
}
  \Sexpr{pretty_numbers(format_integer, data_obs[["
}
  \Sexpr{pretty_numbers(format_integer, data_means[
```

What about sizes?

- | Nasdaq Dealer Market: Double counting.

What about sizes?

- | Nasdaq Dealer Market: Double counting.
- | How are trades reported , an order of 100,000 shares will be broken into several trades.
- | But will a trade against several limit orders reported for each limit order it hits?

Resources

- | TAQ:

[nyse.com/publicdocs/nyse/data/Daily_TAQ_Client_Spec_v3.0d.pdf](https://www.nyse.com/publicdocs/nyse/data/Daily_TAQ_Client_Spec_v3.0d.pdf)

- | ODBC: en.wikipedia.org/wiki/Open_Database_Connectivity

- | github.com

- | rstudio.com

- | Good video:

rstudio.com/resources/webinars/working-with-big-data-in-r/