Transaction Taxes in a Price Maker/Taker Market

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Regulators recently proposed taxing financial transactions.

Goals of such a tax:
- Reduce price volatility
- Raise large revenue from very small tax
- Solve problem of “too much” trading?
- Encourage long-term investing
- Push harmful (?) speculators out of the market

Arguments claimed against such a tax:
- Reduces: securities’ values, market volume, and liquidity
- Distorts market (reduces market efficiency)
- Pushes trade to other venues/countries

Our goal: study costs and (some) benefits of a tax.
Thinking on Transactions Taxes

  - More of a political objective than economic.
Some studies have looked at (analogous?) trading fees:

- Jones and Seguin (1997): lower commissions $\Rightarrow \sigma \downarrow$.
- Liu and Zhu (2009): lower commissions $\Rightarrow \sigma \uparrow$.
- Colliard and Foucault (2012): make/take fees
- Foucault, Kadan, and Kandel (2012): make/take fees; monitoring costs

However, fees often benefit one side of trading.

Degryse, Van Achter, and Wuyts (2012): post-trade fees, broker choice; reserve price $= v_H$ or $v_L$. 
We find a transaction tax:

- Widens quoted, effective spreads by more than tax;
- Lowers likelihood of trading (volume); increases search times.
- Greatly reduces value of limit orders and gains from trade;
- Increases volatility (up to $1.5 \times$);
- Affects markets with market makers more than those without; and,
- Is revenue-optimal for 60–75 bp.

Extending results to handle destabilizing traders.
Microstructure Approach

- Market microstructure:
  - Study of process of price formation, market dynamics.
  - In particular: trading costs, spreads, volume, liquidity.
- Microstructure lets us study many aspects of market quality.
- Thus microstructure is perfect for analyzing tax effects.
Maker/Taker Models

- Maker/taker model:
  - Traders choose to take a price or make new prices.
  - Endogenizes many aspects of market quality.
- Mirrors current realities of trading:
  - Anand *et al* (2005), Hasbrouck and Saar (2009): Traders make *and* take prices.
  - Parlour and Seppi (2008): Mostly limit order markets.\(^1\)
- High-frequency trading: often reduces spread, inside size.
  - Markets with more HFT look more like our model.

\(^1\)Predicted by Black (1971).
Foucault (1999) Model

  - Buyers, sellers take price or make at $v \pm L$.
  - Yields results on spreads, trading rate (volume).
- We extend Foucault (1999) to study costs of transaction tax.
  - Continuous distribution of private reserve values;
  - Fraction $\mu$ of traders who are pure market makers; and,
  - Each trader pays tax of $\tau$/share traded.
- Calibrated model allows studying many market phenomena.
Why Extend Foucault (1999)?

- Traders actively choose price taking versus price making.
  - If tax changes decisions, strategic action is key.
  - Traders only have two reservation values, $v \pm L$
  - $\Rightarrow$ either no effect or eliminates trading.
- Extension allows studying endogenized market phenomena:
  - Traders strategically set bid and ask values;
  - Fail to trade if quotes not appealing to next trader;\(^2\)
  - Differences between quoted and effective spreads;
  - Realized volatility.
- Offers insight into how market metrics (e.g. volume) change with tax

\(^2\)More fine-grained than buy vs sell in Foucault (1999).
Setup

- $v =$ asset value (constant)
- Sequence of iid traders enter market, one per period
- Traders iid; may be market maker w.p. $\mu$ or investor.
  - Private reservation value: $v + d_t$ where $d_t \sim F$.
  - Market maker: $d_t = 0$;
  - Investors: $d_t \sim (0, L^2)$.
- Market continues w.p. $\rho \in (0, 1)$ after each period.
- Each trader taxed $\tau$/share at position entry+exit.
Strategic Quoting

Traders choose strategically whether or not to quote a bid and ask.

- Consider traders at time $t$ (Ilsa), $t + 1$ (Rick), $t + 2$ (Sam).
- Price maker/taker model; Rick strategically chooses:
  - Take: Trade against Ilsa’s quote, or
  - Make: Quote bid $v - \delta$ and ask $v + \beta$ for Sam.
- Rick must also determine his optimal $\delta$ and $\beta$.
- Thus Rick chooses $\max(R_T|d_{t+1}, R_Q|d_{t+1})$ where:
  
  $R_T|d_{t+1} =$ benefit of taking Ilsa’s bid/ask
  
  $R_Q|d_{t+1} =$ benefit of quoting optimal bid, ask for Sam
Ilsa is in the same position. Denote prior trader’s (Ugarte’s?) quotes by $v - \delta_{t-1}$, $v + \beta_{t-1}$.

\begin{align*}
R_T|d_t &= \max(-d_t - \delta_{t-1}, d_t - \beta_{t-1}) - 2\tau \\
R_Q|d_t &= \begin{cases} 
\rho F(-R_Q^{0*} - \delta - 2\tau)(d_t + \delta - 2\tau) + \\
\rho F(-R_Q^{0*} - \beta - 2\tau)(\beta - d_t - 2\tau)
\end{cases} \\
R_Q^{0*} &= \int_{\Omega} R_Q|d_t dF
\end{align*}

Ilsa also faces strategic choice:

- Take known benefit $R_T|d_t$ or expected benefit $R_Q|d_t$?

\footnote{Assuming that $R_Q^{0*}$ exists.}
Characterizing Propositions

We characterize equilibrium by proving some propositions.

1. Rick will only want to buy from Ilsa, sell to her, or quote.
2. If $d_t > 0$, the bid-ask quote is shifted higher ($\beta > \delta$).
3. Bid-ask spread $\delta + \beta > 4\tau = \text{twice trader’s tax}$.
4. Quoting benefit is positive: $R_Q |d_t > 0$.
5. For $F = \Phi$ (Gaussian): unique Markov perfect equilibrium.
6. For $F = \Phi$, bid-ask spread $\delta + \beta \leq \frac{L}{R_Q^0 + 4\tau} + 4\tau$.

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And likewise for $d_t < 0$. 
Consider a market calibrated to typical characteristics:

- Value $v = $20; private reservation values $v + d_t$.
- $P(\text{trading continues next period}) = \rho = 0.9$
- Transaction tax $\tau$: $0–$0.10/share traded (0–50 bp).
- Traders: $d_t \overset{iid}{\sim} F$
  - Market-maker: w.p. $\mu$, $d_t = 0$.
  - Investor: w.p. $1 - \mu$, $d_t \overset{iid}{\sim} N(0, L^2)$
- Reserve price volatility $L = $0.5 = 2.5%$^5$

$^5$If daily net trades $\Rightarrow$ 40% annual volatility.
Optimal Bid and Ask Offsets

Optimal quote: bid @ $v - \delta$, ask @ $v + \beta$ where

\[
\delta = L \frac{(1 - \mu)\Phi(B(\delta)) + \mu I(B(\delta) \geq 0)}{(1 - \mu)\phi(B(\delta))} - dt + 2\tau, \tag{4}
\]

\[
\beta = L \frac{(1 - \mu)\Phi(A(\beta)) + \mu I(A(\beta) \geq 0)}{(1 - \mu)\phi(A(\beta))} + dt + 2\tau. \tag{5}
\]

and

\[
B(\delta) = \frac{-R_Q^{0*} - \delta - 2\tau}{L}, \tag{6}
\]

\[
A(\beta) = \frac{-R_Q^{0*} - \beta - 2\tau}{L}. \tag{7}
\]
Solving for Equilibrium

- Solving for equilibrium is a bit involved.
- For a given tax $\tau$, fraction of market makers $\mu$:
  1. Iterate over “all possible” $d_t$’s.
     - By symmetry, just iterate from (-3,0).
     - Take care with center of distribution; tail expectation.
  2. For each $d_t$, find optimal $R_Q|d_t$.
     - Need 3 cases for which/none of indicator functions active.
  3. Then compute expectation of all $R_Q|d_t$’s.
  4. Back to (1); iterate until stable $R_Q^0 = E(R_Q)$ found.
  5. With $R_Q^0$, re-iterate for expected spread, trading rate.
- Then redo all of the above for another tax rate.
Quoted Spread

From no tax to 50 bp tax:

- Quoted spread: 175→240 bp (no MMs), 240→345 bp (50% MMs).
- More MMs make spread slightly more sensitive to tax.
- More MMs compete for fill: quoted spread ↑.
Optimal Quoting Benefit $R_Q^{0*}$

From no tax to 50 bp tax:
- $R_Q^{0*}$: $0.16 \rightarrow 0.08$ (no MMs), $0.13 \rightarrow 0.05$ (50% MMs)
- 80bp → 40bp → 65bp → 25bp
- More MMs: value of quoting more sensitive to tax.
- MMs compete for fill: quoting value ↓
Fill Rate

- Fill rate: 42% $\rightarrow$ 26% (no MMs), 19% $\rightarrow$ 8% (50% MMs)
- Roughly: Fill rates halved.
- More MMs make fill rate more sensitive to tax.
Search Costs

- Search costs (1/fill rate): 5→11.5 (no MMs), 2.3→4 (50% MMs)
- Roughly: search costs doubled.
- More MMs make search costs more sensitive to tax.
Simulated Trades

- Can then simulate trading \((N = 5000)\) to see more effects.
- Example quote and price paths for no tax:

No MMs, No Tax  

50% MMs, No Tax
Effective Spreads are lower with MM (opposite of quoted).

Effective Spread (bp) vs. tax (bp)
Gains from Trade vs. tax (bp)

- Gains from trade $:= \max(R_T|d_t, R_Q|d_t)$
- MMs: $d_t = 0$, compete for fill
  - Lowers $R_Q|d_t$; and, MMs do not trade with MMs.
  - $\Rightarrow$ both effects lower gains from trade.
- 50 bp tax roughly halves gains from trade.
Volatility

- No MMs: Highest volatility at 0 tax, least sensitive.
- 50% MMs: lowest volatility below 40 bp, most sensitive.
- At high taxes, lower volatility w/o MMs than with MMs.
- Taxes increase volatility, up to $1.5 \times$. 

Volatility ($) vs. tax (bp)
Tax Revenues

- Revenue-optimal tax: 60–75 bp.
- More MM$ \Rightarrow$ lower optimal tax.
Conclusion

We find that a transaction tax:

- Widens quoted and effective spreads by $> 2 \times$ the tax;
- Reduces the likelihood of trading (volume);
  - $\Rightarrow$ increases search times.
- 50 bp: Halves value of limit orders and gains from trade;
- Yields higher price volatility (less stable prices); and,
- Is revenue-optimal for 60–75 bp. (!)

Currently being extended to add destabilizing traders:

- De Long et al. (2006) positive feedback traders.
- Preliminary evidence: Tax still increases volatility.