# Transact taxes in a price maker/taker market

Rosenthal, Dale W.R. and Thomas, Nordia Diana Marie

University of Illinois at Chicago, University of Wisconsin - La Crosse

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# TRANSACTION TAXES IN A PRICE MAKER/TAKER MARKET

DALE W.R. ROSENTHAL° AND NORDIA D. M. THOMAS*

Abstract. We develop a price maker/taker model to study how a financial transaction tax affects markets. We find taxes widen quoted and effective spreads by more than twice the tax. Taxes increase volatility slightly (without intermediation) to significantly (with intermediation). High taxes may halve volumes and gains from trade while doubling search costs. Measures of market quality are more affected by taxes in markets with intermediaries. Investors and intermediaries competing for liquidity can triple search costs and increase quoted spreads while decreasing effective spreads. We also find revenue-optimal rates of 60–75 bp. Our results are particularly relevant to markets with high-frequency trading or thin depth. *JEL: C72, D44, G19*

Keywords: transaction tax, Tobin tax, market microstructure, limit order model, high-frequency trading, search costs

Regulators have recently discussed taxing financial transactions. Supporters of such a tax claim it would deter (presumably harmful) speculation, and some tout the potential revenue that could be raised and its impact on the national budget deficit. Opponents of a transaction tax argue it will lead to reduced liquidity and make trading more costly, and many note that this would make trading too costly for some investors. To assess these claims, we model a price maker/taker market and then study how a transaction tax affects that market. Our model is relevant for policy makers and academics

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○ Department of Finance, University of Illinois at Chicago. * Corresponding author: Department of Finance, 406A Wimberly Hall, University of Wisconsin-La Crosse 1725 State Street, La Crosse, WI, 54601. Tel. +1 312 545 4092, Email: nthomas@uwlax.edu.

considering the effects of enacting, changing, or repealing a transaction tax. The model also yields insights into how varying levels of intermediation and transaction taxes affect markets. Since investors and intermediaries compete for liquidity, this work is especially applicable to markets with high-frequency traders or thin liquidity.[1]

Many supporters of a tax cite Tobin's (1974) proposal of a 1% tax on foreign exchange transactions to reduce short-term speculation after the end of Bretton Woods.[2] He hoped to "throw sand in the wheels of the market" thereby allowing nations greater leeway in exchange rate policies and in staving off monetary crises. Policy makers supporting a 'broad-based' securities transaction tax include Larry Summers, US Representative Peter DeFazio, German Chancellor Angela Merkel, and Keynes (1936).[3] These policy makers argue that most short-term financial transactions are driven by speculators causing excessive volatility in the financial markets.[4]

Opponents are mostly academics who suggest that a Tobin-like transaction tax would have negative effects overall. They argue that such a tax would increase price volatility due to reduced trading volume and increased bid-ask spreads, not reduce excess price volatility, decrease security values, and increase the cost of capital.

Since this debate is contentious, policy makers would benefit greatly from theoretical models. Models would also help policy makers assess various tradeoffs in implementing a tax as well as informing policy in circumstances that have not been previously observed. For unusual or rare policies such as transaction taxes, theoretical models may be our only hope of assessing

[1] "Thin" liquidity means that the size of the inside bid-ask quotes are small.
[2] This idea was reiterated and expounded upon in Tobin (1978) and Tobin (1984).
[3] A broad-based tax is one that would be levied on all financial securities such as stocks, bonds, options and futures with only government securities exempt.
[4] The October 1987 market crash, the 6 May 2010 "flash crash," and the recent financial crisis are often cited as examples cum outcomes of harmful speculation.

potential policy effects. Since transaction taxes would directly affect the microstructure of markets — market efficiency, liquidity, and volatility — we examine taxes using microstructure models. While microstructure is a very different field from macroeconomics, microstructure effects like secondary market liquidity are of vital importance to funding liquidity and the efficacy of primary markets.

Our model features a sequence of traders who strategically choose price taking versus price making. This mirrors market behavior observed by Anand *et al.* (2005) and Hasbrouck and Saar (2009). The model is similar in spirit to Foucault (1999) but allows for a range of private reserve valuations as well as varying proportions of pure market makers. These sources of variation enable us to study the impact of a transaction tax on investors and market makers. The sequential market structure is most applicable to markets which are thin or effectively thin. Black (1971) noted that markets in which traders compete (on speed) to get the best price are effectively thin. Therefore, this model has policy implications for markets with high-frequency traders. A nice feature of our model is that we can examine search costs without many of the assumptions or heavy mathematical machinery present in other models.[5] In particular, we make no assumption about the arrival rates of a match; rather, matching happens endogenously by traders setting prices to achieve their equilibrium maximum benefit.

We expected *ex-ante* that a transaction tax of $\tau$/share would increase the spread by $2\tau$ as price makers recover the tax through their quotes. We also expected this widened spread to yield (i) lower fill rates/volume, (ii) more limit orders (vs market orders), (iii) greater execution costs, and (iv) longer times for buyers and sellers to find each other (aka search costs).

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[5]Search costs are a measure of liquidity defined by Lippman and McCall (1986) as "the time until an asset is exchanged for money."

We find that participants who must pay a tax widen their quotes and are less likely to trade. For small values of the tax, a 1bp increase in tax decreases the volume traded by 0.2%–0.3%. Furthermore, we find that the maximal revenue raised is about half of the naïve assumption of tax × pre-tax volume. For a 50 bp tax without market makers, we find quoted spreads widen by 36%; effective spreads widen by 38%; investors pay 2.6 times the tax; volatilities increase by 7%; volumes decrease by 38%; gains from trade fall by 50%; and, search costs increase to 1.6 times the untaxed costs. If half the potential traders are market makers, we predict quoted and effective spreads widen by 43%; investors pay 2.8 times the tax; volatility increases by 59%; volume decreases by 46%; gains from trade fall by 60%; and, search costs increase to 2.2 times the untaxed costs. The revenue-optimal tax of 62–75 bp increases spreads by about 50%; decreases volume by about 50%; and, reduces the benefits of providing liquidity by about two-thirds. As to the effects of intermediation in high-frequency or "thin" markets, we find that having more market makers increases spreads by up to 37%–43% for half the potential traders being market makers. This occurs because investors and market makers compete for liquidity. In general, we find that market makers make market quality more sensitive to taxes.

## 1. Literature Review

Historically, securities transactions taxes have been proposed, enacted, modified, and even repealed in various countries.[6] Summers and Summers (1989), Stiglitz (1989), Kupiec (1995), Frankel (1996), Felix and Sau (1996), Palley (1999), and Baker (2000) have all proposed 'Tobin-like' taxes for various financial markets. ul Haq *et al.* (1996) and Spahn (2002) suggest a

[6]Countries which have considered or enacted financial transaction taxes include Australia, Brazil, China, France, Germany, India, Japan, Singapore, Sweden, Taiwan, and the United Kingdom.

0.1% to 0.2% tax would balance the opposing objectives of lowering price volatility due to speculation *and* maintaining market liquidity. Both studies point out, however, that such a modest tax would likely have little impact on speculative activity. Pollin *et al.* (2003) consider a securities transaction tax for US financial markets as "one feature of a new financial architecture aimed at contributing to financial stabilization."

Studies opposed to transaction taxes include Friedman (1953), Grundfest and Shoven (1991), Campbell and Froot (1994), Kupiec (1995), Habermeier and Kirilenko (2001), and Forbes (2001). Schwert and Seguin (1993) give a comprehensive overview of arguments both for and against a securities transaction tax.

Empirical studies disagree as well. Umlauf's (1993) study of Sweden imposing a 1% transaction tax in 1984 (and doubling it in 1986) found that 30% of equity trading volume moved to London, the market for interest rate options dried up, market volatility did not decline, and volume did not return to pre-tax levels when the tax was repealed in 1987.[7] Liu and Zhu (2009) found the October 1999 deregulation of full commissions in Japan significantly increased price volatility in the equities market. Jones and Seguin (1997), however, found that reducing commissions on the New York Stock Exchange (NYSE) and American Stock Exchange (AMEX) in 1975 was followed by reduced market volatility in the following year.

Habermeier and Kirilenko (2001) posit three reasons for this disagreement. First, securities transaction taxes are often enacted with other policy shifts confounding causal inferences about changes in market measures. Second, measuring the tax reduction of noise trading is difficult since there is no way to determine if decreased market volume is due to informed traders

[7]For the years 1988–1990 between 48% and 52% of trading volume in Swedish equities occurred in London. This may explain Swedish opposition to a transaction tax.

or noise traders. Third, if asset prices change because of the tax, there is no way to determine if this was due to anticipation of the tax, trading moving to other venues, or untaxed securities. We would add two more reasons. First, comparing empirical studies is harder because securities transaction taxes vary in size and scope — from 0.13 basis points (bp) to 528 bp (5.28%). Second, reducing commissions is not the same as reducing a tax since lower commissions reduce rent-extraction and expose financial firms to more competition. Thus initial conditions of profitability and competition might explain the differences between Liu and Zhu (2009) and Jones and Seguin (1997). All of these issues make excellent arguments in favor of theoretical studies.

Very few microstructure-based studies have been done. Dupont and Lee (2007) investigated a transaction tax using a Glosten and Milgrom (1985) model incorporating spread and depth. They found that higher information asymmetry made the tax more likely to decrease market liquidity. Mannaro *et al.* (2008) used heterogeneous agent types to study transaction taxes in simulated markets. For a single market, they found volatility increased as the number of orders decreased; for two competing markets, traders tended to avoid the taxed market — which exhibited higher volatility than the untaxed market. Cipriani and Guarino (2008) found that a tax caused a laboratory financial market (sequential trading, one market maker) to cease trading during large disparities between an asset's price and true value. However, reduced noise trading caused by the tax offset some of the induced market inefficiency. Pellizzari and Westerhoff (2009) showed that if adequate liquidity were maintained a tax could help stabilize both double-auction and dealer markets.[8] Otherwise, a tax reduced trading volume which increased

[8]Maintenance of adequate liquidity for such findings to be relevant is more likely in a dealer market where a market maker is expected to maintain a two-sided market.

volatility as each trade had greater price impact. Demary (2010) used an agent-based framework to show that tax rates above 0.1% destabilized the market and that taxes had stronger effects on more risk-averse traders.

Our model also allows inference about search costs. Typically, search models assume sequential search and bargaining and explicitly detail the search process (for example, assuming Poisson arrival rates to the market). Buyers and sellers seek to trade one unit of an asset with pairings assigned by a matching process. Paired traders bargain in an attempt to agree on a price of the asset and re-enter the market until an agreement is reached. Examples of such models include Diamond (1982), Rubenstein and Wolinsky (1985), Gale (1987a,b), Binmore and Herrero (1988), Lu and McAfee (1996), Mortensen and Wright (2002), Duffie *et al.* (2005), and Duffie *et al.* (2010). Our model is more similar to how Lo and MacKinlay (1990) looked at nonsynchronous trading.

## 2. Model

Our limit order book model is similar to the simple price maker/taker model of Foucault (1999).[9] The economy has one risky asset with fundamental value $v$. Traders arrive sequentially, one per unit of time, and have a spectrum of idiosyncratic reserve values $v + d_t$ where $d_t \overset{iid}{\sim} F$. We assume that $F$ is a distribution with a mean of zero and finite variance: a trader with $d_t < 0$ would prefer to sell, a trader with $d_t > 0$ would prefer to buy.

We assume that traders have heterogeneous reasons for trading: alpha (real or perceived), business risks to hedge, and inventory risk to eliminate being a few examples of such reasons. We also assume traders have access to

[9]Traders in the Foucault (1999) framework have only two possible reservation values, $v \pm L$ which occur with equal probability. We allow a range of private valuations and quotes based on these private valuations because for only two possible valuations, as in Foucault (1999), a tax would either have no effect or eliminate all trading.

inventory or borrowed stock which allows them to sell without constraints.[10] For simplicity and tractability, quotes live for only one period; and, to prevent gaming, the market continues at each period with non-unit probability $\rho$. Traders realize the utility of their trade (whether through expected return or by benefiting from a risk-reducing hedge) immediately following trading.

2.1. **Strategic Quoting.** Each trader seeks to trade one unit of the risky asset. Trading may be done by taking the prevailing bid-ask quote (*i.e.* sending a market order) or by making a new bid-ask quote (sending limit orders which replace the prevailing quote).[11] Thus each trader plays a game against the next trader. To clarify the exposition, we will call these two traders Ilsa (the time $t$ trader) and Rick (the time $t+1$ trader).[12]

Traders pay tax at both position entry and exit. Thus if Ilsa trades with Rick, each is debited a transaction tax of $\tau$. Consequently, one could conjecture that if Ilsa quotes a bid and ask, she will shade her quotes, *i.e.* pass on some amount of the tax to Rick by quoting a bid of $v - \delta_t$ and an ask of $v + \beta_t$, where $\delta_t$ and $\beta_t$ are functions of the tax $\tau$. Ilsa must solve for these equilibrium offsets to decide the optimal amount of the tax to (potentially) pass on to Rick. This strategic price shading causes $\delta_t$ and $\beta_t$ to be functions of Ilsa's reservation value $v + d_t$, the distribution of Rick's unknown reservation value $v + d_{t+1}$, and the transaction tax $\tau$. A layout of the model framework is shown in Figure 1.

[10]Institutional traders generally have access to borrowable stock via brokerage customer's holdings as well as market making inventory.

[11]This yields phenomena seen in markets such as failure to trade when no one of the opposite preference arrives in the market. Since trading is not guaranteed, the model helps explain how equilibrium fill rates/volumes are affected by changes in market setup.

[12]While we use this language to discuss the game played by each trader, this should not be construed as implying a repeated game. The setup is a sequential trader model: as time goes by, a sequence of unique traders arrive. Thus if a trader Sam first plays the game at any time $s$, we know that Sam will never play it again.

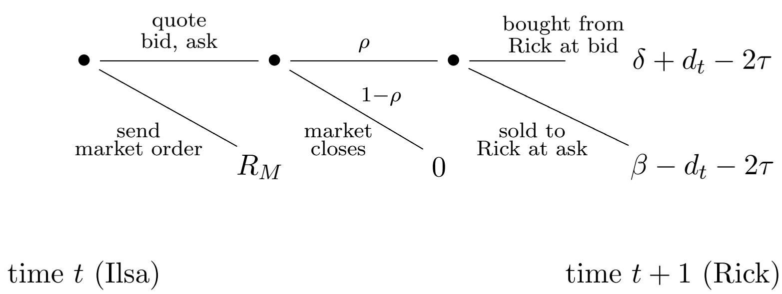


FIGURE 1. Details of trader's revenues in different scenarios. The revenue for a market order is given by $R_M = (\delta_{t-1}+d_t)\wedge(\beta_{t-1}-d_t)-2\tau$. With probability $\rho < 1$, the market continues if a trader has placed limit orders (quoted a bid and an ask). If the market continues, the underlying asset price can be the same or higher with probability $k$ or the same or lower with probability $(1-k)$.

Because the game played every time period is between the current and next-period trader, the solution takes a form which does not depend on past states. Therefore, we can assume that prices are static (*i.e.* $\Delta v = 0$) without loss of generality and solve for equilibrium $\delta$ and $\beta$ (without time subscripts). Were $\Delta v \neq 0$, we could merely shift the $d_t$ distribution $F$ (as well as $\delta$ and $\beta$) by $E(\Delta v)$. Were $\text{Var}(\Delta v) > 0$, we could scale $F$ to have a variance of $\text{Var}(\Delta v) + \text{Var}(d_t)$. Therefore, while we work with static prices, the results here are applicable to stochastically-evolving prices.

We determine optimal trade strategies by working forward from time $t$. Traders who decide to quote choose not to take the current bid or ask price; they prefer the expected value of their optimal quote to that of the current quote. This optimal expected value defines the boundary between sending a market order and quoting and varies with the reservation value $v + d_t$. Ilsa's expected quote revenue, $R_Q$, then has the form:

$$
\begin{aligned}
R_Q = \rho P(\text{Rick sells at bid})(&\overbrace{v + d_t}^{\substack{\text{utility or}\\ \text{sale price}}} - \overbrace{(v-\delta)}^{\substack{\text{bought}\\ \text{from Rick}}} - 2\tau) \\
+ \rho P(\text{Rick buys at ask})(&\underbrace{v+\beta}_{\substack{\text{sold to}\\ \text{Rick}}} - \underbrace{(v+d_t)}_{\substack{\text{utility or}\\ \text{buy price}}} - 2\tau).
\end{aligned} \tag{1}
$$

$$
\begin{aligned}
&= \rho P(\text{Rick sells at bid})(\delta + d_t - 2\tau) \\
&\quad + \rho P(\text{Rick buys at ask})(\beta - d_t - 2\tau).
\end{aligned} \tag{2}
$$

The next trader, Rick, enters the market at time $t+1$ and decides whether to trade against Ilsa's quote or quote a bid and ask for the following trader based on his optimal quote revenue $R_Q^{0*}$. Rick makes this decision according to the logic in Table 1.

| Condition | Action |
|---|---|
| $v - \delta - (v + d_{t+1}) - 2\tau > R_Q^{0*}$ $\Rightarrow d_{t+1} < -R_Q^{0*} - \delta - 2\tau$ | Sell at Ilsa's bid |
| $v + d_{t+1} - (v + \beta) - 2\tau > R_Q^{0*}$ $\Rightarrow d_{t+1} > R_Q^{0*} + \beta + 2\tau$ | Buy at Ilsa's ask |
| Otherwise | Quote new bid and ask |

TABLE 1. Rick's decision rules for placing a market order to trade against Ilsa's quote when the asset price is stochastic. If none of the conditions are satisfied, Rick will quote his own bid and ask instead.

The time $t$ trader, Ilsa, knows nothing about the preference for the risky asset of the time $t+1$ trader, Rick. Therefore, she solves for *his* optimal fixed-point quote revenue $R_Q^{0*}$ given the unconditional distribution of $d_{t+1}$ and setting $R_Q = R_Q^{0*}$ in equation (2).

Ilsa maximizes her quote revenue by setting the partial derivatives, $\frac{\partial R_Q}{\partial \delta}$ and $\frac{\partial R_Q}{\partial \beta}$, to 0 and solving. This implies that her optimal strategy is to bid at $v - \delta$ and ask for $v + \beta$, where the bid and ask offsets are respectively,[13]

$$\delta = \frac{F(B(\delta)) - f(B(\delta))(d_t - 2\tau)\frac{\partial B}{\partial \delta}}{f(B(\delta))\frac{\partial B}{\partial \delta}}, \tag{3}$$

$$\beta = \frac{F(A(\beta)) - f(A(\beta))(-d_t - 2\tau)\frac{\partial A}{\partial \beta}}{f(A(\beta))\frac{\partial A}{\partial \beta}}, \tag{4}$$

where $F$ and $f$ are the unconditional cdf and pdf of $d_{t+1}$, $B(\delta) = -R_Q^{0*} - \delta - 2\tau$ is the expected benefit of Rick taking liquidity at Ilsa's bid, and $A(\beta) = -R_Q^{0*} - \beta - 2\tau$ is the (sign-flipped) expected benefit of Rick taking liquidity at Ilsa's asking price.

2.2. **Distributional Assumptions.** To see how this model behaves, we assume that $d_t$ comes from a mixture of a normal distribution and an atomic distribution. Thus traders are of two types, pure market makers ($d_t = 0$) and investors with a fraction $\mu$ of traders being pure market makers.[14]

$$d_t \overset{iid}{\sim} \begin{cases} 0 & w.p.\ \mu \\ N(0, L^2) & w.p.\ 1 - \mu. \end{cases} \tag{5}$$

With this assumpton about $d_t$, we can rewrite the unconditional expected quote revenue, $R_Q$, as:

$$\begin{aligned} R_Q = {} & \rho(1-\mu)\Phi\left(\frac{-R_Q^{0*} - \delta - 2\tau}{L}\right)(\delta + d_t - 2\tau) \\ & + \rho(1-\mu)\Phi\left(\frac{-R_Q^{0*} - \beta - 2\tau}{L}\right)(\beta - d_t - 2\tau) \\ & + \rho\mu\mathbb{I}(-R_Q^{0*} - \delta - 2\tau \geq 0)(\delta + d_t - 2\tau) \\ & + \rho\mu\mathbb{I}(-R_Q^{0*} - \beta - 2\tau \geq 0)(\beta - d_t - 2\tau) \end{aligned} \tag{6}$$

[13]Note that we have used the symmetry of $F$ to express the probability of Rick trading at Ilsa's asking price in equation 2 via $F$ instead of $1 - F$.

[14]Assigning $d_t = 0$ makes market makers indifferent between buying and selling; the effect of inventory risk is ignored. However, market makers with inventory risk can be thought of as belonging to the population of traders with normally-distributed $d_t$'s.

where $\Phi(\cdot)$ is the standard normal cumulative distribution function. Solving for $R_Q^{0*}$ requires breaking the spectrum of $d_t$'s into three regions: where neither indicator function is active, where the first indicator function is active, and where the second indicator function is active. (Solving in these last two regions requires constrained optimization.) We then find the optimum across the three regions. The indicator functions capture if the next trader is a market maker who takes the quoted bid or ask, so we know that both will not be active simultaneously.

## 3. Numerical Analysis

To study how a transaction tax would affect market quality, we analyze how traders are affected by differing levels of such a tax $\tau$ ranging from 0 to 50 bp. We also study the effect of taxes for different proportions of market makers to all potential traders. The mean reservation value is $v = \$20$ with a reservation value standard deviation of $L = \$0.50$ (2.5% of $v$), and the market continuation probability $\rho = 0.9$. We look at both the average effect across the market and the effect for market makers.

From the basic dynamics with these parameters, we can see that we already have a rich model. Figure 2 shows that even the dynamics for a market with static $v$ and no taxes displays the sort of variation in trade prices seen in real data. We can also note that having more market makers tends to stabilize the range in which a security trades.

### 3.1. **Quotes and Volume.**

Figure 3 shows that the quoted spread without market makers increases by 42% from \$0.68 with no tax to \$0.97 with a 50 bp (\$0.10) tax; with 50% market makers the quoted spread increases 38% from \$0.69 to \$0.95. At $\tau = 50$ bp (\$0.10), the change in the quoted spread is 2.9× and 2.6× the change in the tax, for markets without market makers and with 50% market makers. In other words: traders pay 160%–190% more

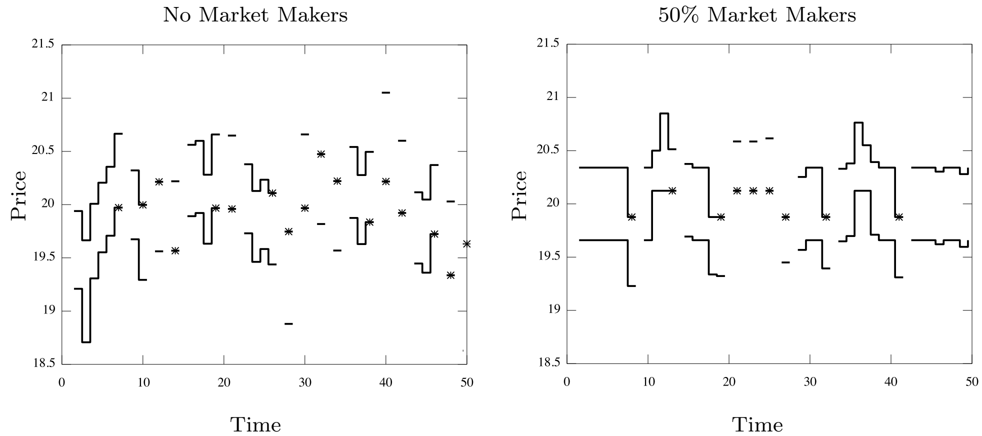


FIGURE 2. Simulated trades (stars) and quotes (lines) for a market with no transaction tax. The plot on the left is for a market with no market makers; the plot on the right is for a market where 50% of those arriving at the market are market makers. Note that the market with market makers displays more bid-ask bounce yet trades in a tighter range: All trades occur between \$19.50 and \$20.50 while trades occur outside this range for the market without market makers (left). Both show that the model dynamics mimic behavior that is seen in real data.

than the tax. Figure 4 shows about a 50% drop in the volume (fill rate) at a tax of 50 bp regardless of the presence of market makers.

Finally we note that the average traders' benefit from trading without market makers decreases from \$0.15/share to \$0.08/share; with 50% market makers, this benefit decreases from \$0.13/share to \$0.06/share. Thus the gains from trade fall by about 47% and 54%, respectively.[15] To the extent that market makers might have costs comparable to their expected revenues, we could expect market makers exiting the market more quickly than this model suggests. This might suggest that high-tax regimes would look more

[15]One way to think about this figure is of expected returns or revenues. If we add in any assumption of costs, the profitability would fall by even more. Thus the likelihood of trading and the fill rate would drop by even more than is shown here.

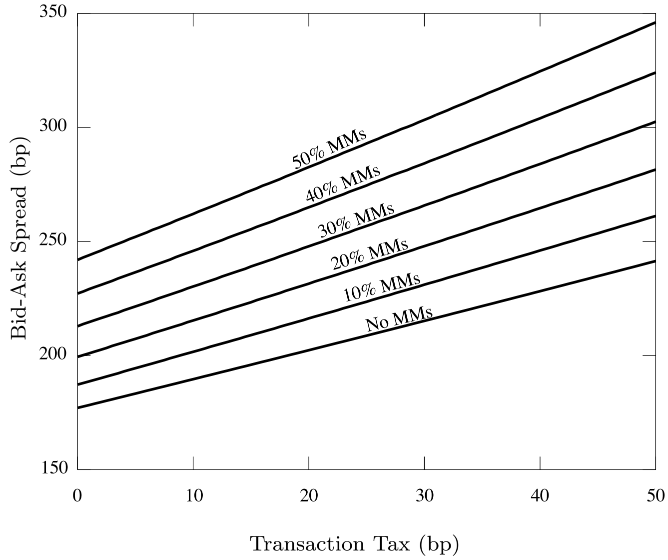


FIGURE 3. Quoted bid-ask spread (in basis points) vs transaction tax rates (in basis points). Curves show 10% increments of market makers, from none to half of potential traders. Traders have a reservation value offset of 0 (market makers) or with volatility of 2.5% (investors). Above 20 bp, the marginal spread is greater than the marginal tax; and, above 25 bp of tax, the wider spread means investors pay more than the tax.

like the models without market makers (even higher quoted spreads, lower fill rates, and lower expected returns for those who are not market makers).

3.2. **Search Costs.** In *Trading and Exchanges*, Harris says, "Trading is a search problem. [. . . ] Sellers seek buyers willing to pay high prices. Buyers seek sellers willing to sell at low prices." Typically, search models take the form of sequential search and bargain models. For this reason, our model is well-constructed to allow insight into search costs. However, we must forgo caring about the intermediate sequential search and bargain processes, and only focus on how long it takes *in toto* until a trade occurs. Since Lippman and McCall (1986) view liquidity as "the time until an asset is exchanged for

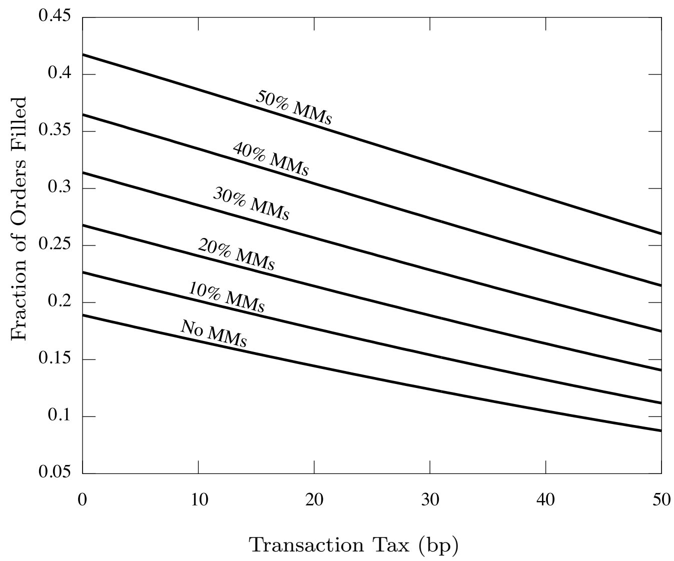


FIGURE 4. Fill rate vs transaction tax rates (in basis points). Curves are shown for 10% increments of market makers, from none to half of potential traders being market makers. Traders have a reservation value offset of 0 (market makers) or with volatility of 2.5% (investors). The fill rate drops 55%–59% at a tax rate of 50 bp.

money", we study how a transaction tax affects the average time between trades.

If the probability of a fill is $P_f$ (*i.e.* the probability a limit order will be executed), we can infer the waiting time between trades, $t_w$, by inverting the probability of a fill: $t_w \propto {P_f}^{-1}$. We know that Ilsa's probability of a fill is related to Rick's (time $t+1$) decision to trade.

$$P_f = P(\text{next trader sells at bid}) + P(\text{next trader buys at ask}). \tag{7}$$

$$\begin{aligned} =&\rho(1-\mu)\Phi\left(\frac{-R_Q^{0*}-\delta-2\tau}{L}\right)+\rho(1-\mu)\Phi\left(\frac{-R_Q^{0*}-\beta-2\tau}{L}\right) \\ &+\rho\mu P(-R_Q^{0*}-\delta-2\tau\geq 0)+\rho\mu P(-R_Q^{0*}-\beta-2\tau\geq 0) \end{aligned} \tag{8}$$

Using this equation, we get the results shown in Figure 6.

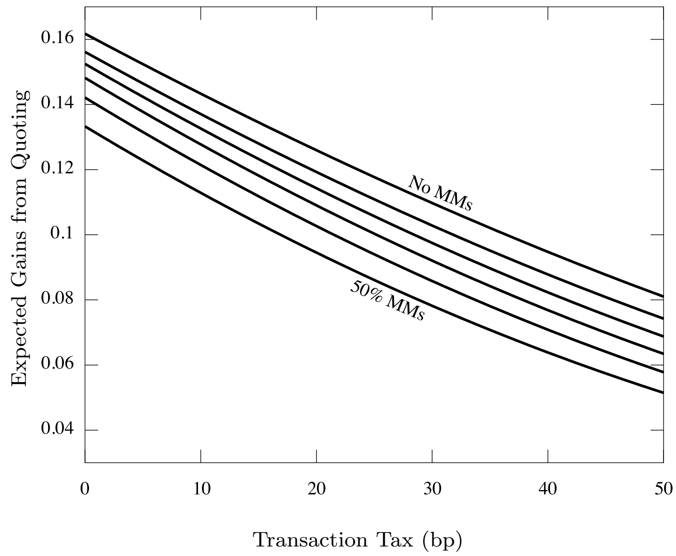


Figure 5. Gains from quoting vs transaction tax rate (in basis points). Curves show 10% increments of market makers, from none to half of potential traders. Traders have a reservation value offset of 0 (market makers) or with volatility of 2.5% (investors). Above 20 bp, note that gains from trade drop about 47% for a 50 bp tax without market makers and about 54% for a 50 bp tax with half the potential traders being market makers. The gains from trade can be thought of as revenues or expected returns. Note, however, that this does not include costs (which are not modeled).

We find that, in general, as the level of the tax increases, the waiting times between trades rises. While the results are qualitatively similar for markets with different fractions of market makers, the effect of a transaction tax on search costs is much greater for markets with more market makers. Without market makers, a transaction tax of 25 bp would increase search times by about 36% and a tax of 50 bp would increase search times by about 110%. With 50% market makers, a transaction tax of 25 bp would increase search times by about 13% and a tax of 50 bp would increase search times by about 116%. Thus while market makers reduce spreads, the benefits of

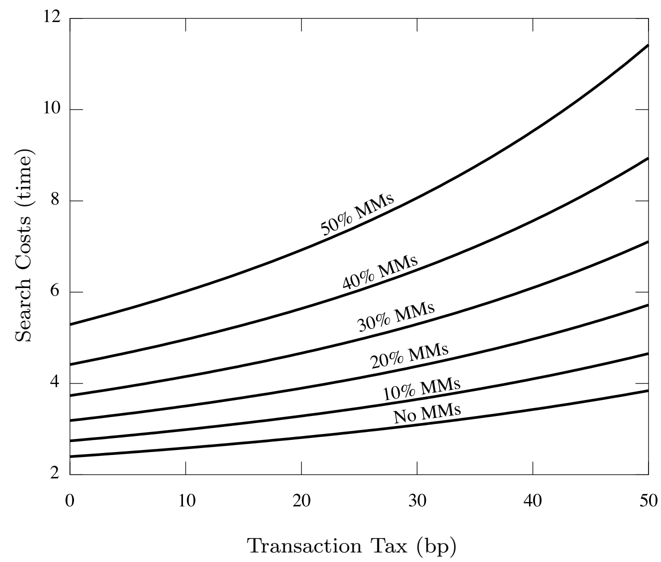


FIGURE 6. Search costs (expected waiting times to trade) vs transaction tax rate (in basis points). Curves show 10% increments of market makers, from none to half of potential traders. Traders have a reservation value offset of 0 (market makers) or with volatility of 2.5% (investors).

their intermediation disappear more quickly as taxes increase compared to the benefits of other traders.

3.3. **Revenue-Optimal Tax Rates.** Since one argument for transaction taxes is their revenue-generating capabilities, we consider the maximal government revenue possible in our model. The Laffer curve in Figure 7 shows that the maximum government revenue of 6–16 cents per share would be generated at tax rates of 62–75 bp with lower taxes being revenue-optimal with greater fractions of market makers.

At these tax rates, however, the quoted spread would widen to between 270 bp (no market makers) and 370 bp (50% market makers) — about 50% greater than untaxed spreads. Fill rates would fall to between 21% (no market makers) and 10% (50% market makers) — volume declines of 52%–55%. In line with this, search costs more than double (2.1×–2.2×) compared to

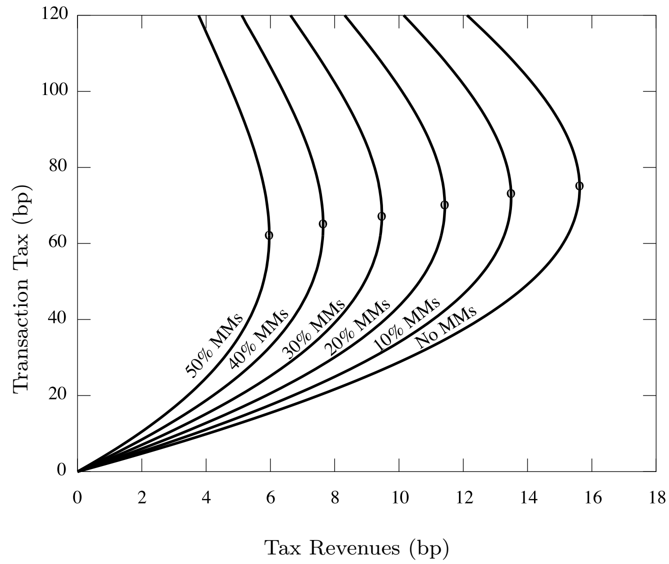


FIGURE 7. Laffer curve: Transaction tax rates vs equilibrium tax revenues (in basis points) with revenue-optimal rates indicated by a circle. Curves show 10% increments of market makers, from none to half of potential traders. Traders have a reservation value offset of 0 (market makers) or with volatility of 2.5% (investors). Note that the revenue-optimal tax would be between 62 bp and 75 bp and that tax revenue falls by about two-thirds for half of the potential traders being intermediaries. Thus more developed markets (with more intermediation) would yield less expected revenue per order under a transaction tax.

untaxed search costs. The value of quoting declines by over two-thirds or more (over 70% for 50% market markers).[16] All of these results suggest conditions that would likely induce trading to move elsewhere. Finally, the revenue raised falls by over two thirds between markets with no intermediation and those with 50% of potential traders being market makers. This suggests that more developed markets are more sensitive to taxation and may yield lower expected revenue per order.

[16]Since a trader may choose not to quote if the prior quote is more appealing, the quote revenue is a lower bound to gains from trade.

3.4. **Simulation Results.** Not all of the comparative statics we are concerned about are easily found by solving the game played by Ilsa and Rick. We examine the effective (*i.e.* realized at trade time) bid-ask spread, the gains from trade, and price volatility. While we could try to derive the volatility from the quoted spread using Roll (1984), that would ignore the endogeneity of when trade occurs and thus would be inaccurate.

For each level of tax explored, we generate a random sequence of 5,000 traders with iid reservation value offsets. For each trader, we record their trading decision (make or take prices). If a trade occurs, we record the direction (buy/sell), the price, and the expected gain from trade.

The plot in Figure 8 (effective spread) shows that without market makers, adding a 50 bp tax increases the effective spread by 38%. If half the potential traders are market makers, a 50 bp tax increases the effective spread by 45% versus the untaxed spread. Finally, adding market makers increases the quoted spreads (Figure 3), but decreases the effective spread across all levels of tax.

Figure 9 (volatility) shows that without market makers, adding a 50 bp tax increases the volatility by 2%. If half the potential traders are market makers, a 50 bp tax increases the volatility by 60% versus the untaxed volatility. Furthermore, these lines cross, so above a tax of about 42 bp, a market without market makers is less volatile than a market with half the potential traders being market makers. This may explain differences seen in various analyses: that sometimes a tax reduces volatility and sometimes a tax raises volatility. Either way, market quality in markets with market makers may be much more fragile than in markets which lack market makers.

Since market makers are intermediaries, they are unlikely to take a directional bet. Therefore we might expect that they will trade closer to the mean reservation value and thus for lower expected revenue than most other

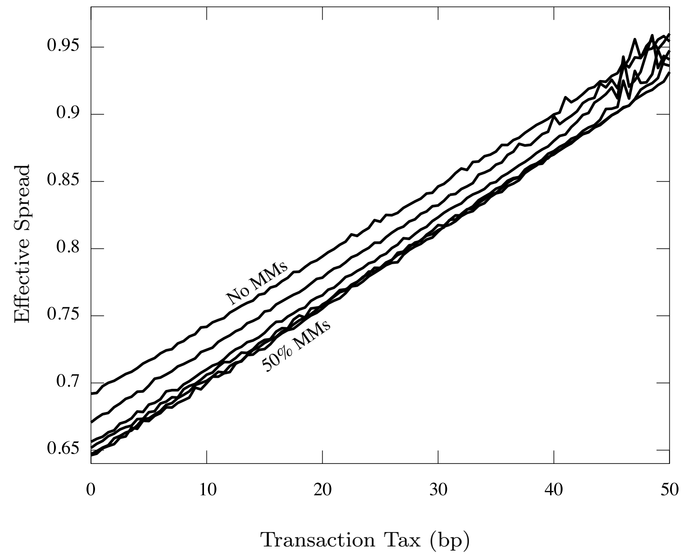


FIGURE 8. Effective spreads (spreads at trade times) vs transaction tax rate (in basis points). Curves show 10% increments of market makers, from none to half of potential traders. Traders have a reservation value offset of 0 (market makers) or with volatility of 2.5% (investors). Note that more market makers reduce effective spreads while higher taxes increase effective spreads.

traders. This is indeed the case: increasing the fraction of market makers lowers the *average* gains from trade. (One could also view this as market makers reducing the dispersion in beliefs about prices.) The average gains from trade in a market without market makers decreases by about 23% for a 50 bp tax; if half the potential traders are market makers, a 50 bp tax decreases the average gains from trade by about 27%.

While market makers intermediate for lower returns, we might wonder if they make up for lower expected returns with higher volume. Figure 10 (gains from trade) shows the total gains from trade. Unfortunately, that does not seem to be the case. The plot shows that the total gains from trade are higher without market makers. (Obviously, this is not accounting

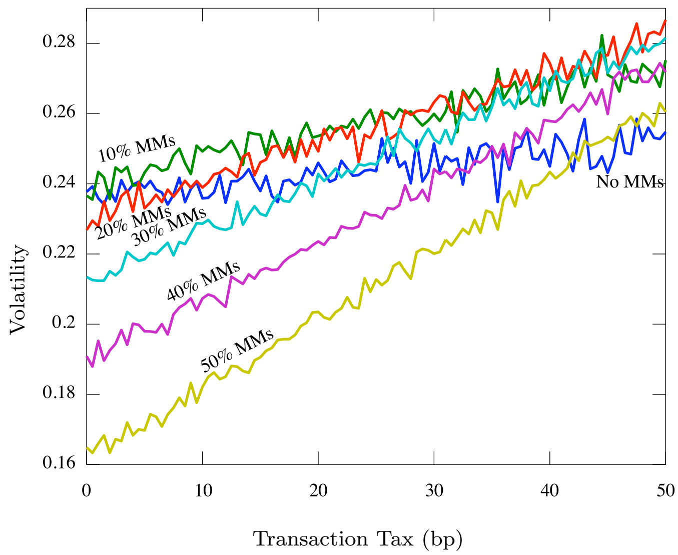


FIGURE 9. Volatility (of trade prices) vs transaction tax rate (in basis points). Curves show 10% increments of market makers, from none to half of potential traders. Market makers have a reservation value offset of 0 while investors have an offset with volatility of 2.5%. Note that more market makers leads to lower volatility yet makes market volatility more sensitive to taxes.

for transactions costs.) For markets with and without market makers, the total gains from trade drop about 50% for a 50 bp tax.

3.5. **Summary.** The resulting market characteristics are summarized in Table 2 for four tax rates of interest (0 bp, 10 bp, 25 bp, and 50 bp) and two fractions of potential market makers (0% and 50%). We choose these rates because 10 bp is one European Commission-recommended and France-approved rate, 25 bp was proposed by US Representative DeFazio, and 50 bp was the largest such tax ever proposed in the US.

## 4. Conclusion

Following the recent financial crisis, regulators have tried to assure the public that such a crisis would not recur, that those responsible would be

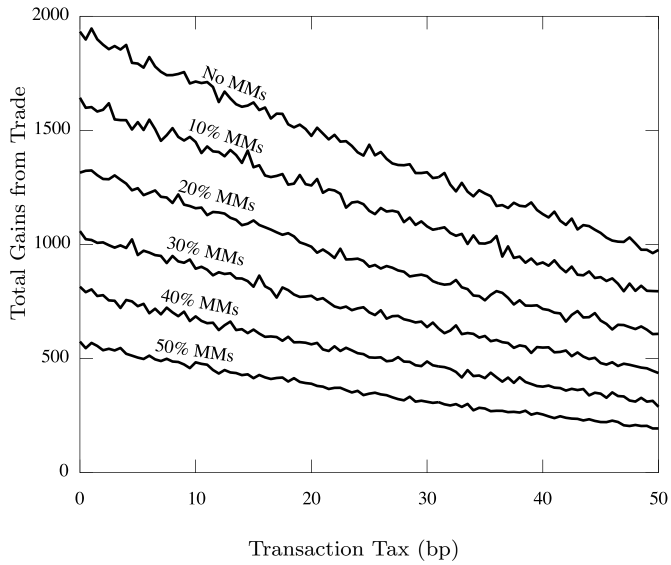


Figure 10. Total gains from trade vs transaction tax rate (in basis points) for 10000 simulated trades. Curves show 10% increments of market makers, from none to half of potential traders. Traders have a reservation value offset of 0 (market v makers) or with volatility of 2.5% (investors). Note that more market makers leads to lower gains from trade (total and average) since market makers trade for small margins. For markets with and without market makers, a 50 bp tax decreases the total gains from trade by about 50%.

penalized, and that the financial industry would pay for being bailed out. Some policy makers have proposed a securities transaction tax to meet these goals with the idea that a tax would reduce price volatility; encourage long-term investing; raise large amounts of revenue from a very small tax; and, push harmful speculators out of the market.[17] Peel (2010) reported that German Chancellor Angela Merkel is "pushing for a Europe-wide financial transaction tax by 2012" which she expects to raise "an extra €2B per year for the German budget." Opponents of transaction taxes, however, have argued that a transaction tax will reduce liquidity and increase trading costs

[17]See Eichengreen *et al.* (1995), Stiglitz (1989), and Summers and Summers (1989) for a review of these issues.

| **A: No market makers** | Transaction tax $\tau =$ | | | |
|---|---|---|---|---|
| Relevant Measures | 0 bp | 10 bp | 25 bp | 50 bp |
| quoted bid-ask spread, $s$ | \$0.35 | \$0.38 | \$0.42 | \$0.48 |
| effective bid-ask spread, $\bar{s}$ | \$0.69 | \$0.74 | \$0.82 | \$0.95 |
| price volatility | 1.19% | 1.18% | 1.22% | 1.27% |
| fill rate, $P_f$ | 42% | 39% | 34% | 26% |
| quote revenue, $R_Q^{0*}$ | \$0.146 | \$0.132 | \$0.111 | \$0.078 |
| total gains from trade | \$966 | \$857 | \$719 | \$488 |
| **B: 50% market makers** | Transaction tax $\tau =$ | | | |
| Relevant Measures | 0 bp | 10 bp | 25 bp | 50 bp |
| quoted bid-ask spread, $s$ | \$0.48 | \$0.53 | \$0.59 | \$0.69 |
| effective bid-ask spread, $\bar{s}$ | \$0.65 | \$0.71 | \$0.79 | \$0.93 |
| price volatility | 0.82% | 0.91% | 1.06% | 1.30% |
| fill rate, $P_f$ | 19% | 17% | 13% | 9% |
| quote revenue, $R_Q^{0*}$ | \$0.130 | \$0.114 | \$0.091 | \$0.060 |
| total gains from trade | \$287 | \$242 | \$173 | \$97 |

Table 2. Effects of policy-relevant transactions taxes for a \$20 asset where investors have reservation value volatility of 2.5% and market makers have reservation value equal to the average reservation value. Effects are averaged over the populations of potential traders for populations with no market makers (Panel A) and 50% market makers (Panel B). The 10 bp tax is a level recently suggested by the European Commission, and the 25 bp and 50 bp levels have been proposed in the US. Total gains from trade is for a simulated sequence of 5000 potential traders.

making trading too expensive for some investors. They have also said a tax such as the broad-based one proposed by DeFazio will be difficult to implement (especially across asset classes), will distort the market by reducing market efficiency, and will push traders to other venues or countries.[18]

Policy makers cannot easily experiment with their markets; and, it is not clear how informative empirical studies are to proposed taxes on other markets. We developed this model both to guide policy makers and to help academics understand how different aspects of market quality may be related or affected by policy changes. The resulting sequential trader model is very

[18]See, for example Habermeier and Kirilenko (2001), Campbell and Froot (1994), and Schwert and Seguin (1993).

clean in its assumptions — a contribution to the market microstructure literature in its own right. However, the model also has much to say about the effects of intermediation in thin/fast markets as well as the effects of financial transaction taxes. In the future, we will extend the model to study the effects of competing market makers or a specialist.

What the model suggests should give pause to the hasty imposition of transaction taxes. Declining market volume could be an indication that some traders (possibly speculators) are being pushed out by the tax, as desired. However, we also find that quoted and effective spreads widen, volatility increases, and both the benefits of providing liquidity and gains from trade decrease. Depending on their urgency, investors trading in this lower liquidity environment might be subject to higher adverse selection. Any one of these could be harmful; in concert, they could hobble traders with genuine needs to trade. Furthermore, these changes in the secondary market would likely reduce the ability of companies to raise funds in the primary market; thus a tax could reduce job and wealth creation.

In markets without market makers, we find that a 50 bp tax increases quoted and effective spreads by more than one-third; investors pay 2.6 times the tax; volatility increases slightly; volume drops by almost 40%; search costs increase by 60%; and, the benefit of providing liquidity and gains from trade are halved. In markets with half the traders being market makers, we find that a 50 bp tax increases quoted and effective spreads by more than 40%; investors pay 2.8 times the tax; volatility increases by almost 60%; volume drops by about 45%; search costs increase by 120%; the benefit of providing liquidity drops by over 50%; and, gains from trade decrease by nearly two-thirds. We find that the revenue-optimal tax would be between roughly 60 bp and 75 bp; however, these rates would be even more harmful to market quality.

Because the model is one of sequential traders, it is especially applicable to markets where liquidity is thin (where inside bid-ask quotes are of small size). As many have noted, and Black (1971) predicted, this includes markets where high-frequency trading is prevalent since those markets can be effectively thin. In thin markets, market makers can reduce liquidity for other traders if they compete to trade. This would be particularly relevant for high-frequency traders who are not only intermediaries but also engage in proprietary trading. Since this describes a large portion of current securities markets, we believe this analysis is important for policy makers considering implementing a financial transaction tax.

While it was not our goal, the model also yields information about the effects of intermediation in thin/fast markets. Increasing the proportion of actors who are market makers may increase quoted bid-ask spreads while simultaneously decreasing effective (realized) spreads. This may help disentangle seemingly conflicting findings between these two measures of liquidity. Increasing the fraction of market makers also reduces volatility, and gains from trade (since markets are more efficient with market makers). Volume also decreases. While this could be viewed negatively, it might merely reflect that markets are more efficient and thus there are fewer opportunities to make outsized profits.

Finally, increasing the fraction of market makers causes markets to be more sensitive to transaction taxes. Under a tax, volatility increases to exceed that of a market lacking intermediaries. Volume also drops by a greater fraction as do the benefits of providing liquidity and gains from trade. Thus markets with high levels of intermediation may respond differently to a tax than markets with little or no intermediation. This is crucial for policy makers because it suggests that empirical studies need to be examined very carefully because their findings may not be applicable to more developed markets with higher levels of intermediation.

## References

Anand, A., S. Chakravarty, and T. Martell. (2005)., "Empirical evidence on the evolution of liquidity: Choice of market versus limit orders by informed and uninformed traders." *Journal of Financial Markets*, 8, 288–308.

Baker, D. (2000)., "The Case for a Unilateral Speculation Tax in the United States." Briefing paper, Center for Economic and Policy Research, Washington, DC.

Binmore, K. G. and M. J. Herrero. (1988)., "Matching and Bargaining in Dynamic Markets." *Review of Economic Studies*, 55, 17–31.

Black, F. (1971)., "Towards a Fully Automated Exchange, Part 1." *Financial Analyst's Journal*, 27, 28–35,44.

Campbell, J. Y. and K. A. Froot (1994)., "Securities Transaction Taxes: What About International Experiences Migrating Markets?" In "Transaction Taxes: False Hopes and Unintended Consequences," Chicago: Irwin Professional Publishing.

Cipriani, M. and A. Guarino. (2008)., "Transaction Costs and Informational Cascades in Financial Markets." *Journal of Economic Behavior and Organization*, 68, 581–582.

Demary, M. (2010)., "Transaction Taxes, Greed and Risk Aversion in an Agent-Based Financial Market Model." *Journal of Economic Interaction and Coordination*, 1–28.

Diamond, P. A. (1982)., "Aggregate Demand Management in Search Equilibrium." *Journal of Political Economy*, 90, 881–894.

Duffie, D., N. Gârleanu, and L. H. Pedersen. (2005)., "Over-the-counter Markets." *Econometrica*, 73, 1815–1847.

Duffie, D., G. Giroux, and G. Manso. (2010)., "Information Percolation." *American Economic Journal: Microeconomics*, 2, 100–111.

Dupont, D. Y. and G. S. Lee. (2007)., "Effects of Securities Transaction Taxes on Depth and Bid-Ask Spread." *Economic Theory*, 31, 393–400.

Eichengreen, B., J. Tobin, and C. Wyplosz. (1995)., "Two Cases for Sand in the Wheels of International Finance." *Economic Journal*, 105, 162–172.

Felix, D. and R. Sau (1996)., "On the Revenue Raising Potential and Phasing in of the Tobin Tax." In M. ul Haq, I. Grunberg, and I. Karl (eds.), "The Tobin Tax: Coping with Financial Volatility," Oxford: Oxford University Press.

Forbes, K. J. (2001)., "Comment on "Securities Transaction Taxes and Financial Markets"." *IMF Staff Papers*, 181–186.

Foucault, T. (1999)., "Order flow composition and trading costs in a dynamic limit order market." *Journal of Financial Markets*, 2, 99–134.

Frankel, J. (1996)., "How Well Do Foreign Exchange Markets Work: Might a Tobin Tax Help?" In M. ul Haq, I. Grunberg, and I. Karl (eds.), "The Tobin Tax: Coping with Financial Volatility," Oxford: Oxford University Press.

Friedman, M. (1953)., *Essays in Postive Economics*. Chicago: University of Chicago Press.

Gale, D. (1987a)., "Bargaining and Competition Part I: Characterization." *Econometrica*, 54, 785–806.

Gale, D. (1987b)., "Bargaining and Competition Part II: Existence." *Econometrica*, 54, 807–818.

Glosten, L. R. and P. R. Milgrom. (1985)., "Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders." *Journal of Financial Economics*, 14, 71–100.

Grundfest, J. A. and J. B. Shoven. (1991)., "Adverse Implications of a Securities Transactions Excise Tax." *Journal of Accounting, Auditing and Finance*, 6, 409–442.

Habermeier, K. and A. A. Kirilenko. (2001)., "Securities Transaction Taxes and Financial Markets." *IMF Staff Papers*, 165–180.

Harris, L. (2002)., *Trading and Exchanges: Market Microstructure for Practitioners*. Oxford: Oxford University Press.

Hasbrouck, J. and G. Saar. (2009)., "Technology and liquidity provision: The blurring of traditional definitions." *Journal of Financial Markets*, 12, 143–172.

Jones, C. and P. Seguin. (1997)., "Transaction Costs and Price Volatility: Evidence from Commission Deregulations." *American Economic Review*, 82, 728–737.

Keynes, J. M. (1936)., *The General Theory of Employment, Interest and Money*. London: Macmillan.

Kupiec, P. H. (1995)., "A Securities Transactions Tax and Capital Market Efficiency." *Contemporary Economic Policy*, 93, 101–112.

Lippman, S. A. and J. J. McCall. (1986)., "A Operational Measure of Liquidity." *American Economic Review*, 76, 43–55.

Liu, S. and Z. Zhu. (2009)., "Transaction Costs and Price Volatility: New Evidence from the Tokyo Stock Exchange." *Journal of Financial Services Research*, 36, 65–83.

Lo, A. W. and A. C. MacKinlay. (1990)., "An Econometric Analysis of Nonsynchronous Trading." *Journal of Econometrics*, 45, 181–211.

Lu, X. and R. P. McAfee. (1996)., "The Evolutionary Stability of Auctions over Bargaining." *Games and Economic Behavior*, 15, 228–254.

Mannaro, K., M. Marchesi, and A. Setzu. (2008)., "Using an Artificial Financial Market for Assessing the Impact of Tobin-Like Transaction Taxes."

*Journal of Economic Behavior and Organization*, 67, 445–462.

Mortensen, D. T. and R. Wright. (2002)., "Competitive Pricing and Efficiency in Search Equilibrium." *International Economic Review*, 43, 1–20.

Palley, T. I. (1999)., "Speculation and Tobin Taxes: Why Sand in the Wheels Can Increase Economic Efficiency." *Journal of Economics*, 69, 113–126.

Peel, Q. (2010)., "Berlin Reveals Drastic €80bn Cuts." *Financial Times*.

Pellizzari, P. and F. Westerhoff. (2009)., "Some Effects of Transaction Taxes Under Different Microstructures." *Journal of Economic Behavior and Organization*, 72, 850–863.

Pollin, R., D. Baker, and M. Schaberg. (2003)., "Securities Transaction Taxes for U.S. Financial Markets." *Eastern Economic Journal*, 29, 527–558.

Roll, R. (1984)., "A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market." *Journal of Finance*, 39, 1127–1139.

Rubenstein, A. and A. Wolinsky. (1985)., "Equilibrium in a Market with Sequential Bargaining." *Econometrica*, 53, 1133–1150.

Schwert, G. W. and P. J. Seguin. (1993)., "Securities Transaction Taxes: An Overview of Costs, Benefits and Unresolved Questions." *Financial Analyst's Journal*, 49, 27–35.

Spahn, P. B. (2002)., "On the Feasibility of a Tax on Foreign Exchange Transactions." Report to the federal ministry for economic cooperation and development, Federal Republic of Germany.

Stiglitz, J. (1989)., "Using Tax Policy to Curb Speculative Short-Term Trading." *Journal of Financial Services Research*, 3, 101–115.

Summers, L. H. and V. P. Summers. (1989)., "When Financial Markets Work Too Well: A Cautious Case for a Securities Transactions Tax." *Journal of Financial Services Research*, 3, 261–286.

Tobin, J. (1974)., *The New Economics a Decade Older*. Princeton: Princeton University Press.

Tobin, J. (1978)., "A Proposal for International Monetary Reform." *Eastern Economic Review*, 4, 153–159.

Tobin, J. (1984)., "On the Efficiency of the Financial System." *Lloyd's Bank Review*, 153, 1–15.

ul Haq, M., I. Grunberg, and I. Karl (1996)., *The Tobin Tax: Coping with Financial Volatility*. Oxford: Oxford University Press.

Umlauf, S. R. (1993)., "Transaction Taxes and the Behavior of the Swedish Stock Market." *Journal of Financial Economics*, 33, 227–240.