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Abstract

Purpose – The securities transaction tax (STT) has been theoretically considered as an important regulation device for decades. However, its role and effectiveness in financial markets is still not well understood both theoretically and empirically. By use of agent-based modeling method, the purpose of this paper is to present a new artificial stock market model with self-adaptive agents, which allows the assessment of the impacts from various levels of STTs in distinctive market environments and thus a comprehensive understanding of the effects of STTs is achieved.

Design/methodology/approach – In the model, agents are allowed to employ the strategies used by the following five types of investors: contrarians, random traders, momentum traders, fundamentalists and exit strategy holders. Specifically, the authors start with the investigation of the dynamics of a tax free benchmark market; then the patterns of market behaviors and the behaviors of various types of investors are discussed with different levels of STTs in markets with mild and high fluctuations.

Findings – The simulation results consistently show that a moderate transaction tax does contribute to market stabilization in terms of reducing market volatility while with a price of mild decrease of market efficiency and liquidity. The findings suggest that a balance between market stability and efficiency could be reached if regulatory authorities introduce STTs to markets discreetly.

Originality/value – This paper enriches the comprehensive understanding of the effects of STT, and gives good explanation about the controversy between Tobin's proponents and anti-Tobin group.

Keywords Economics, Risk management, Complexity, Simulation, Modelling

Paper type Research paper

1. Introduction

The excessive volatilities, speculative bubbles and crashes in financial markets usually lead to catastrophic recessions around the world, so stabilizing the market has always been a critical concern for the financial world. Hence, economists and economic policy makers are highly interested in designing/detecting diverse solutions or regulations to destabilize bubbles in financial markets, such as the stock markets.

Securities transaction tax (STT) has been considered as an important regulation device for decades (see, e.g. Tobin, 1984; Summers, 1989; Stiglitz, 1989; Eichengreen *et al.*, 1995), however, its impacts on financial markets are still not fully uncovered since

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inconsistent results are found in literature for both the theoretical analysis and empirical studies, for a good review see Matheson (2012).

Specifically, there are two main disparate ideas of how STTs may affect the dynamics of financial market. The first one was proposed by Keynes (1936) and Tobin (1978), which were considered as the seminal works introducing STTs into securities markets. They proposed to impose transaction taxes (also known as Tobin taxes) on financial markets to penalize the speculators engaged in short-term trading and claimed that this would reduce the instability of stock markets. After the 1987 stock market crash, many scholars started to follow their trace of research. Summers (1989) and Stiglitz (1989) suggested that the employment of general types of STTs could reduce speculative trading. Shiller (1989, 2002) pointed out that the downscaling of the noise trading and herding effects triggered by the introduction of STTs was efficient in strengthening the stability of markets. Westerhoff and Dieci (2006) obtained similar findings and their model indicated that if a small STT was levied on a market, then speculators would leave the market, thereby making it less volatile.

On contrast, the other idea challenged the assertion that STTs played a vital role in stabilizing securities market. Umlauf (1993) proved that volatility did not decline in line with the introduction of taxes based on the analysis on Swedish stock market. Note that the imposition of a STT indiscriminately discourages both noise traders and well-informed traders, so the effects on the market volatility from the introduction of STTs are confounded (see Campbell and Froot, 1994, pp. 303-308). Lo and Heaton (1995) showed that traders' actions would reinforce market volatility when the trading volume decreased. Consistent to the findings of Umlauf (1993) and Jones and Seguin (1997) found that reduction in transaction cost was followed by a decline in stock return volatility, and Baltagi *et al.* (2006) noticed that the market volatility increased when the tax rate were increased in an emerging market. Moreover, Habermeier and Kirilenko (2003) and Aliber *et al.* (2003) supported the view that the employment of transaction taxes brought down the information efficiency of a market because of its negative effects on price discovery, liquidity and volatility.

Obviously, previous experiences of the application of STTs were gained under quite distinctive market environments, and conclusions made or findings uncovered based on the analysis on data sets from markets with totally different features could be a reason for the disagreements on the impacts from the employment of STTs. In fact, the effects of STTs are vulnerable to be confounded with the effects of other factors, such as the structures of markets, behaviors of the traders', periods of the market and so on, which often causes problems to the understanding of the role and importance of STTs to the markets.

Compared to the traditional empirical approach, agent-based financial market modeling makes the researcher possible to conduct independent simulations on the effects of different STTs while controlling other variability. On the other hand, it can simulate the whole non-stop evolving process of real market, and so relatively more efficient than treating market as a segment. By implementing models for a sequence of different market environments with various STTs, we are not only able to detect the dynamic behaviors of investors but also to reach a comprehensive understanding of the effects of STTs. An earlier example was available in Zeeman (1974). Now Agent-based Computational Finance (ACF) has become a promising tool for policy makers (and researchers) because it enables people to perform sophisticated investigations to gain insights of the effects of the regulatory policies. Detailed review is available at Lebaron (2006), Hommes (2006), Cincotti *et al.* (2008), Demary (2008, 2011) and particularly

Westerhoff (2003), Westerhoff *et al.* (2006, 2008) which are believed to had made significant contributions to this field. However, few studies about STTs and stock market behaviors from the point of ACF are available. To fill in this gap, this paper proposes a new ACF model based on which a comprehensive understanding of the effects of STTs on various markets is achieved. Our model was inspired by the spirit of the model proposed by Westerhoff (2008) which was essentially an exchange rate market model that used as few as two types of market participants' behaviors to capture the dynamics of financial markets efficiently. This paper extends the Westerhoff (2008) model as follows: first, more trading strategies are introduced into the Westerhoff (2008) model to mimic heterogeneous traders' behaviors in real stock markets. Then, an exogenous fundamental noise is added to the stochastic process of market motion with the assumption of independent and identically distributed (IID) normal innovations of the fundamental value. These two extensions equip our model to mimic real stock market more accurately which further provides a platform on which the investigation of the effects of various levels of STTs in markets with different features is feasible.

The remainder of this paper is organized as follows: Section 2 describes our model. Section 3 discusses the simulation results, including the tuning of parameters and discussions of results. By setting different values of the key parameters, we simulate three scenarios to gain a more comprehensive understanding of the dynamics and properties of market. The last section concludes this paper.

2. The model

The model we proposed in this paper was inspired by previous contributions, especially by the models surveyed in Westerhoff (2003) Westerhoff *et al.* (2006, 2008). Since the original models in the survey only considered a very limited number of trading strategies and failed to consider the fundamental value when modeling the dynamics of the markets, there are some room to improve them. In our model, instead of only considering two types of strategies, agents are allowed to employ the strategies used by the following five types of investors: contrarians, random traders, momentum traders, fundamentalists and exit strategy holders. Particularly, fundamental values and exogenous shocks are also introduced to better mimic the real stock market process. Meanwhile, we assume that agents tend to select strategies with competitive historical performances. The models are discussed in detail in this section.

2.1 Market structure assumption

Similar to the traditional artificial financial market, our model is a dynamic model. For the sake of simplicity, we assume that there is only one risk asset in the market and the total number of risk assets available is fixed over time.

We describe the price adjustment process with a so-called price impact function (see, e.g. Farmer and Joshi, 2002). The price in this market is adjusted in response to excess demand as usual. If excess demand is positive, prices rise; otherwise, prices drop. The logarithm of the price of the asset at period t+1 is formulated as:

$$p_{t+1} = p_t + \beta\left(W_t^C D_t^C + W_t^F D_t^F + W_t^R D_t^R + W_t^M D_t^M\right) + \varepsilon_t^p, \tag{1}$$

where p_t is the price of this asset at time t, β is the impact coefficient to the excess demand, D_t^C, D_t^F, D_t^R and D_t^M are the orders generated by contrarians, fundamentalists, random traders and momentum traders, respectively, and W_t^C, W_t^F, W_t^R and W_t^Mdenote their relative quantities accordingly. ε_t^p's are the cumulative effects of other random factors such as price halting, market regulation and so on, and they are assumed to be IID from $N\left(0, \sigma_p^2\right)$.

The fundamental value of a security is set for price deviation analysis. Westerhoff (2006, 2008) argued that since the fundamental value of an exchange rate merely changed, it was reasonable to set its initial value to be a constant. That is, $f_t = c$, where f_t is the exchange rate at time t. However, security prices in stock market change in seconds and are easily impacted by external shocks, so daily price fluctuations are large. Therefore, to be more accurate, we consider external noise and formulate the fundamental values with a random walk described in expression (2):

$$f_t = f_{t-1} + \varepsilon_t, \tag{2}$$

where ε_t's are random noises and are assumed to be IID from $N\left(0, \sigma_e^2\right)$ and f_t now is the value of the related security at time t.

2.2 Candidate investment strategies

Our model assumes that there are five types of participants in the market: contrarians, fundamentalists, random traders, momentum traders and exit-strategy followers. A brief introduction of them is as follows.

2.2.1 Contrarians. This type of investors believes that no trend will hold long. That is, when a price is rising, they tend to sell now since they expect that the price will stop rising and fall down soon and vice versa. Orders from contrarians at time t are modeled as:

$$D_t^C = \beta^C(p_{t-\tau} - p_t) + \varepsilon_t^C, \tag{3}$$

where $\beta^C(p_{t-\tau} - p_t)$ describes transactions triggered by an expectation of future trend. β^C is the reaction parameter to the contrarian trend, τ refers to the time window traders use in the contrarian trading strategy, for example, they may select from 1, 5, 10, 20 days randomly. ε_t^C stands for other factors that may affect the orders and it is assumed that ε_t^C's are IID samples from $N\left(0, \sigma_C^2\right)$.

2.2.2 Fundamentalists. Fundamental traders firmly believe that an asset price will revert to its fundamental value sooner or later, so they tend to place orders on the mispricing securities in stock market which usually create a stabilizing mean reversion effect. Accordingly, fundamental analysis implies buying (selling) the asset when the price is below (above) its fundamental value. Orders triggered by fundamental trading rules at time t may be described as:

$$D_t^F = \beta^F(f_t - p_t) + \varepsilon_t^F, \tag{4}$$

where β^F is a positive reaction parameter and f_t is the fundamental value of the asset at time t. Meanwhile, agents are aware of the asset's true fundamental value and we introduce a random term ε_t^F in the demand function. ε_t^F's are assumed to be IID samples from $N\left(0, \sigma_F^2\right)$.

2.2.3 Random traders. We consider the random trading strategy into the model for the reason that there are many "lazy" traders or liquidity traders in stock markets (especially in emerging markets). Random traders are characterized with zero intelligence and with random buying or selling decisions. Orders from random trading rules at time t are modeled as:

$$D_t^R = \varepsilon_t^R, \tag{5}$$

where it is assumed that ε_t^R's are IID from $N\left(0, \sigma_R^2\right)$.

2.2.4 Momentum traders. They are also known as trend-followers. This type of investors try to exploit trading information of the past price patterns to forecast market trend in the near future. Trend-followers tend to buy assets with arising prices and vice versa. Therefore, orders due to momentum trading rules at time t are:

$$D_t^M = \beta^M (p_t - p_{t-1}) + \varepsilon_t^M, \tag{6}$$

where β^M denotes how strongly the agents react to the price trend. Specifically, the higher β^M is, the more sensitive the agents to price trend. ε_t^M's are assumed to be IID $N\left(0, \sigma_M^2\right)$.

2.2.5 Exit-strategy followers. They leave market or switch to be inactive traders when they have no interests in trading activity or had lost all money in the market. So, no excess demand is created by them.

2.3 Trading strategies selection assumption

Now every agent has five trading strategies available. We assume that selection among strategies according to their attractiveness (we will formally define it later). The more attractive a strategy is, the higher priority that agents choose it. According to Demary (2010, 2011) and Westerhoff (2008), the following fitness functions could formulate the attractiveness of the five strategies, respectively:

$$A_t^C = (\exp[p_{t-\tau}] - \exp[p_t]) D_{t-\tau-1}^C / \tau - tax(\exp[p_t] + \exp[p_{t-\tau}]) \left| D_{t-\tau-1}^T \right| / \tau + dA_{t-1}^C \tag{7}$$

$$A_t^F = (\exp[p_t] - \exp[p_{t-1}]) D_{t-2}^F - tax(\exp[p_t] + \exp[p_{t-1}]) \left| D_{t-2}^F \right| + dA_{t-1}^F \tag{8}$$

$$A_t^R = (\exp[p_t] - \exp[p_{t-1}]) D_{t-2}^R - tax(\exp[p_t] + \exp[p_{t-1}]) \left| D_{t-2}^R \right| + dA_{t-1}^R \tag{9}$$

$$A_t^M = (\exp[p_t] - \exp[p_{t-1}]) D_{t-2}^M - tax(\exp[p_t] + \exp[p_{t-1}]) \left| D_{t-2}^M \right| + dA_{t-1}^M \tag{10}$$

$$A_t^E = 0 \tag{11}$$

where A_t^C, A_t^F, A_t^R, A_t^M and A_t^E are the fitness of being inactive for the five strategy followers, respectively. Notice that the attractiveness of a strategy is decided by two factors simultaneously. First, it relies on the performance (net income after tax) of the specific rule during current period. Second, it depends on its previous performance. The memory parameter $d \in (0, 1)$ measures how fast current fitness is discounted for strategy selection. For $d = 0$, the fitness equals current profits. But the larger the memory parameter is, the more significant the historical performances in determining the fitness. Straightforward speaking, the fitness function is net profit for one investor choosing the corresponding rule. The more attractive a strategy, the more agents will follow it.

Finally, we set the relative quantities of the investors holding each of these strategies as follows:

$$W_t^C = \left(\exp\left(eA_t^C\right)/\left(\exp\left(eA_t^C\right)+\exp\left(eA_t^F\right)+\exp\left(eA_t^R\right)+\exp\left(eA_t^M\right)+\exp\left(eA_t^E\right)\right)\right. \tag{12}$$

$$W_t^F = \left(\exp\left(eA_t^F\right)/\left(\exp\left(eA_t^C\right)+\exp\left(eA_t^F\right)+\exp\left(eA_t^R\right)+\exp\left(eA_t^M\right)+\exp\left(eA_t^E\right)\right)\right. \tag{13}$$

$$W_t^R = \left(\exp\left(eA_t^R\right)/\left(\exp\left(eA_t^C\right)+\exp\left(eA_t^F\right)+\exp\left(eA_t^R\right)+\exp\left(eA_t^M\right)+\exp\left(eA_t^E\right)\right)\right. \tag{14}$$

$$W_t^M = \left(\exp\left(eA_t^M\right)/\left(\exp\left(eA_t^C\right)+\exp\left(eA_t^F\right)+\exp\left(eA_t^R\right)+\exp\left(eA_t^M\right)+\exp\left(eA_t^E\right)\right)\right. \tag{15}$$

$$W_t^E = \left(\exp\left(eA_t^E\right)/\left(\exp\left(eA_t^C\right)+\exp\left(eA_t^F\right)+\exp\left(eA_t^R\right)+\exp\left(9eA_t^M\right)+\exp\left(eA_t^E\right)\right)\right. \tag{16}$$

where e is a parameter that describes how likely traders select the most attractive strategy. The higher e is, the more agents select the strategy with the best performance. If $e=0$, then there is no preference among options and all traders select their rules randomly without regarding the fitness. In other word, e also reflects the rationality of the agents.

3. Simulation

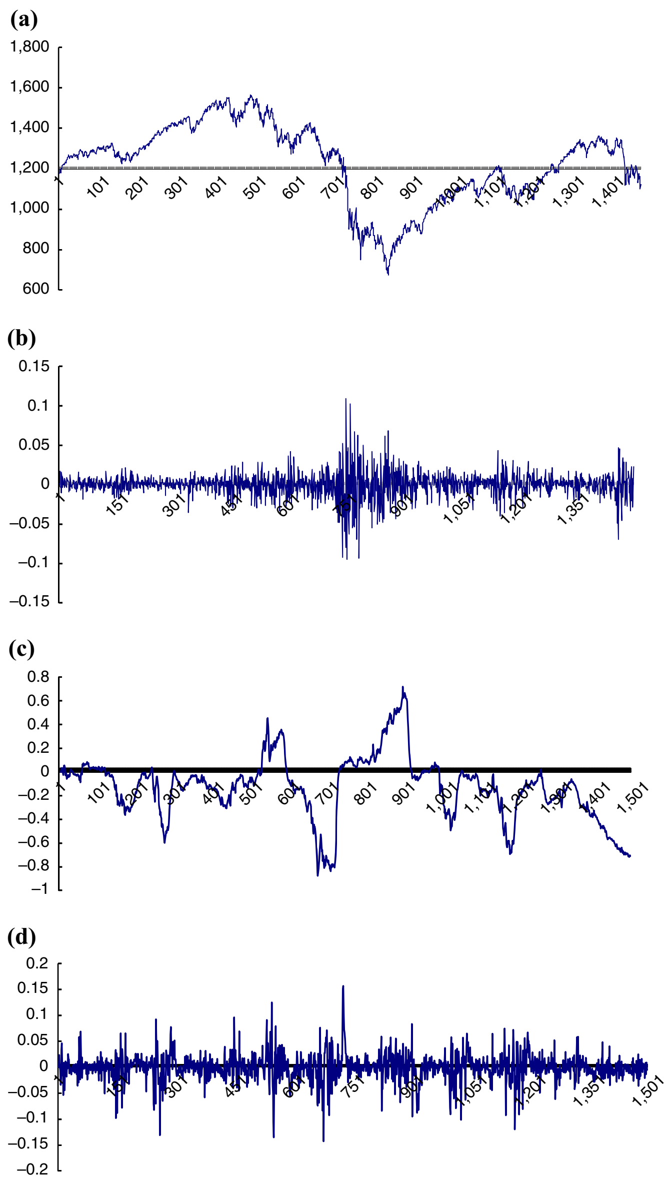
3.1 Model calibration and comparative study

Along with this paper, a Matlab software simulation platform (programs are available upon request) is provided. We aim to find out how a STT affects market via varying tax rates. In our model, market parameters (sufficient sensitivity analysis for every variable was conducted beforehand) are tuned in a way to make sure the artificial market is a good proxy for the real stock market. One simulation step roughly describes a real trading day. To see the efficiency of our agent-based simulation market, a comparative analysis is provided in this section.

Following these principles, we set parameters as below (as benchmark market settings):

- $\sigma_C=0.05$, $\sigma_F=0.01$, $\sigma_R=0.01$, $\sigma_M=0.05$, $\sigma_P=0.01$, and $\sigma_\varepsilon=0.01$;
- $\beta=0.5$, $\beta^C=0.2$, $\beta^F=0.2$, and $\beta^M=0.2$; and
- $e=800$, $tax=0.0$, and $d=0.92$.

we analyze the statistical properties of the simulated time series, which have been generated with 1,500 observations in each stochastic simulation in order to allow the system to get sufficiently close to the asymptotic dynamics and to have time series as long as the daily time series of the S&P 500 index between October 20, 2005 and October 4, 2011. Figure 1 reports the time series plot of the S&P500 and the simulation series generated by our model. Figure 1(a) and (c) suggest that even though price movement path is different, the two price series do display similar features such as



Notes: (a) (From 20 October 2005 to 4 October 2011); (b) daily returns series of the S&P 500; (c) simulated log price series; (d) and simulated returns series

Figure 1. Time series of the S&P 500 index

price fluctuations, crashes and bubbles, mean reversion. From Figure 1(b) and (d), we can see both return series are moving around an approximately zero-mean with time-varying clustering volatility. To give more objective evidences, we turn to the quantitative results in Table I. From Table I, excess kurtosises and heavy tails are detected in both the real and simulated data. Particularly, the Jarque-Bera statistics is far greater than the critical value at 5 percent significance level which suggests that both data samples are not from Normal distributions. Furthermore, all the Q(30) statistics are significant, which suggests linear serial dependencies seem to play a role in the dynamics of stock returns. The values of QS(30) are even bigger, which provide strong evidence of nonlinear dependence, indicating that the conditional distributions of the daily returns are changing through time. This is a symptom of ARCH effects.

In conclusion, the results from Figure 1 and Table I indicate that the model displays statistical properties similar to those of the S&P500 index and can replicate the stylized facts of real financial markets, such as volatility clustering, excess kurtosis, auto-correlation in absolute returns, crashes and bubbles.

3.2 STTs and market behavior

In real market, a trader may change his/her trading strategy because of high transaction cost when STTs exist. Also, a STT's effects on traders' behaviors highly depends on the strategies the traders follow, and the availability of multiple trading strategies further boosts the uncertainty of effects of STTs to a higher level for the whole market. In order to investigate how market behaviors vary under different market conditions, we employ ACF platform to make a more comprehensive study.

For the sake of getting a more quantitative picture of market dynamics, we introduce two useful statistics discussed in Westerhoff (2008):

- The first one measures the distortion in the market:

$$\textit{Price deviation} = \frac{1}{T}\sum_{t=1}^{T} |p_t - f_t| \tag{17}$$

The larger that price deviation is, the worse that market distortion is, the less efficient market we get.

- The other statistic is a proxy for market volatility:

$$\textit{Volatility} = \frac{1}{T}\sum_{t=1}^{T} |p_t - p_{t-1}|, \tag{18}$$

where p_t and f_t are the price and fundamental value of an asset at time t, respectively.

3.2.1 Benchmark market dynamics: market free of STTs. We use the same set of market settings as that in Section 3.1 for the benchmark market, which is essentially a model with no STTs and with relatively moderate level of volatility. Figure 2 shows its dynamics.

From Figure 2, information of the relative quantities of typical investors, market volatility and the deviation between price and fundamental value is demonstrated.

Table I. Statistical properties of S&P500 returns series and simulation returns series

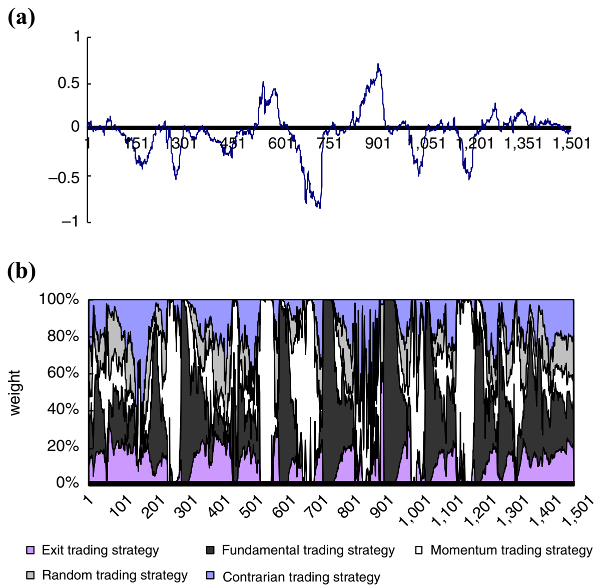
Sample	Mean	SD	Skewness	Kurtosis	JarBra	Q(30)	QS(30)
S&P500	0.0000	0.0153	−0.30	11.53	4,569.46	100.06	4,256.60
Model	−0.0004	0.0261	−0.18	8.06	1,612.13	290.60	1,184.10

Note: Q(30) and QS(30) statistics represent the Ljung – Box Q statistics for autocorrelation of return series and absolute return series, respectively

Specifically, panel (a) shows that the simulation model produces patterns, such as bubbles and crashes. By comparing panels (a) and (b), when technical trading strategies, especially momentum trading strategy, possess large proportions of the total transactions, the margin of price deviation expands. However, when fundamental trading strategy dominates the market, the deviation drops low. This indicates that it is those agents who employ technical trading strategies that drive the market instable, and fundamentalists stabilize the market.

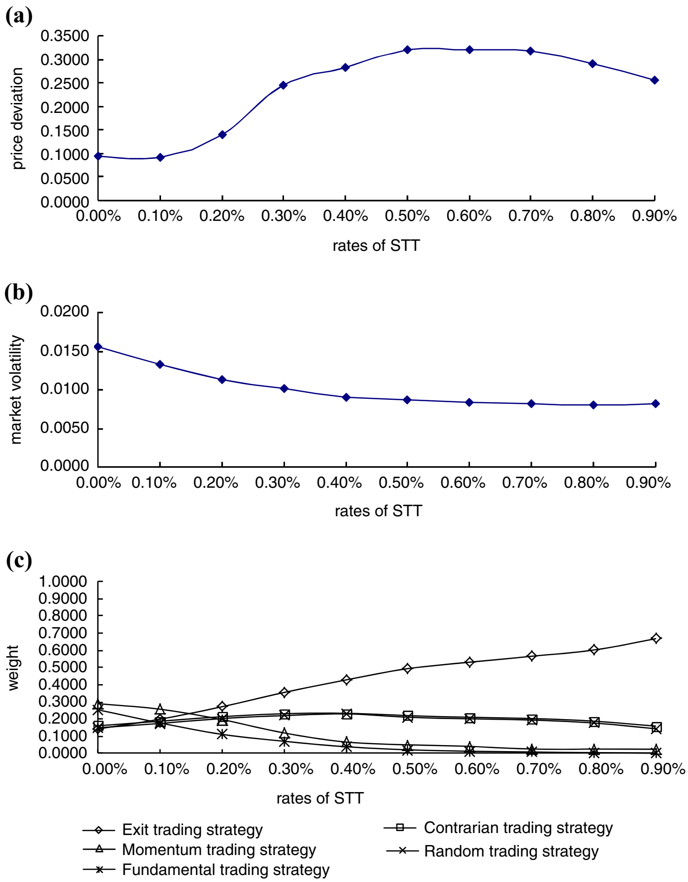
3.2.2 Effects of a STT on a benchmark market with moderate volatility. The main concern of this subsection is to see the effects of a STT on a market with moderate volatility. Specific effects considered are the impacts on market volatility and on the deviation between price and fundamental values. Further, we see how an investor's trading strategies change when STTs vary. For a numerical understanding, we use the same settings for the parameters as those in Section 3.1 except for changing the tax rate from 0.0 to 0.9 percent.

Figure 3 shows that as the tax rate increases, the exit trading strategy holders become more dominate in market while the proportions of technical and fundamental analysts drop significantly. Especially, when the rate goes above 0.3 percent, the proportion of fundamentalists goes below 10 percent. In that situation, the market is full of exit-strategy followers and technical analysts. The direct consequences of the aforementioned changes are the market activeness reduction and market volatility decrease though price deviation stays in a high level. The results partly confirm Tobin's view; however, negative divergences still exist.



Notes: (a) Shows the margin of price deviation, deviation margin is referred to the difference between log of price and fundamental value; (b) depicts the weights of the trading strategies, respectively(exact values of the weights are available from the author upon requests)

Figure 2.
The dynamics of the basic model in the time domain



Notes: (a) Shows the margin of price deviation, deviation here is referred to the average of absolute difference between log of price and fundamental value; (b) depicts market volatility defined as average of absolute difference between market prices; (c) presents the weights of investor trading strategies. All statistics are estimated as averages over 50 simulation runs, each containing 1,500 observations

Figure 3.
The dynamics of the model with transaction taxes in the time domain

The summary of the results is as follows:

(1) It reveals two main points. On the one hand, the introduction of taxes increases the transaction costs, which impairs the interests of investors and thus enhance market stability. On the other hand, if the level of price deviation rises, taxes undermine market pricing mechanism, and it coincides with the viewpoint of anti-Tobin group.

(2) When a high level of Tobin-tax is employed, trading interests of both fundamentalists' and trend-followers' drop rapidly, and a majority of investors tend to leave market. In other words, market volatility decreases at the expense of market efficiency.

(3) When tax rate is below 0.2 percent, a desirable balance between market efficiency and volatility is reached. At this point, market volatility decreases significantly while the margin of price deviation stays stable, and fundamentalists still remains dominant.

(4) Contrarians are relatively less sensitive to the change of tax rates. So, strategy of contrarians seems to be a sound choice for all market environments. This confirms some of the previous findings, such as the ones from De Bondt and Thaler (1985).

3.2.3 Effects of a STT on a market with high volatility. The effects of a STT on a market with high volatility are also of great importance/interests to researchers and policy makers. Via a sensitivity analysis, we see that market volatility reaches its maximum when the memory parameter is as high as 0.98. Simultaneously, market volatility increases with a high strategic sensitivity. Since the maximal value of strategy sensitivity could be infinite theoretically, we take $e = 5{,}000$ in this study to make a point.

Specifically, we set:

- $\sigma_C = 0.05$, $\sigma_F = 0.01$, $\sigma_R = 0.01$, $\sigma_M = 0.05$, $\sigma_P = 0.01$, and $\sigma_\varepsilon = 0.01$;
- $\beta = 0.5$, $\beta^C = 0.2$, $\beta^F = 0.2$, and $\beta^M = 0.2$; and
- $e = 5{,}000$, $d = 0.98$, and the tax rate from 0.0 to 0.9 percent.

The results are displayed in Figure 4.

Similar results as those in Section 3.2.2 are found, which means that the general conclusion in Section 3.2.2 also holds here. Below is a detailed summary of the results for this scenario:

(1) Overall, in a market with high volatility, increasing tax rate impairs the interests of all traders, no matter what trading strategies they follow. Consequently, market volatility decreases though market distortion remains at a high level. It means that market becomes illiquid and inefficient.

(2) Exit-strategy followers dominate the market promptly. When tax rate surpasses 0.3 percent, more than 90 percent agents retreat from market and the total proportion of the followers of other strategies drops down to almost zero. It is the huge volatility that triggers this trend.

(3) All types of investors are relatively more sensitive to taxes if a market is with a high volatility. High level of transaction tax severely impairs traders' interests in investment, and both short-term speculators and long-term fundamentalists are heavily impacted.

(4) When tax is controlled within 0.2 percent, although fundamentalists are still dominant, market volatility decreases dramatically rapidly with an insignificant increase of margin of price deviation (even decreasing when tax rate is 0.1 percent). Therefore, it is a relatively safe choice to set tax rate at 0.2 percent level to balance stability and efficiency.

To sum up, the introduction of security transaction tax in financial markets is favorable to penalize the speculative trading as well as to prevent financial crisis, which is consistent with the assertion of Keynes and Tobin. However, our results

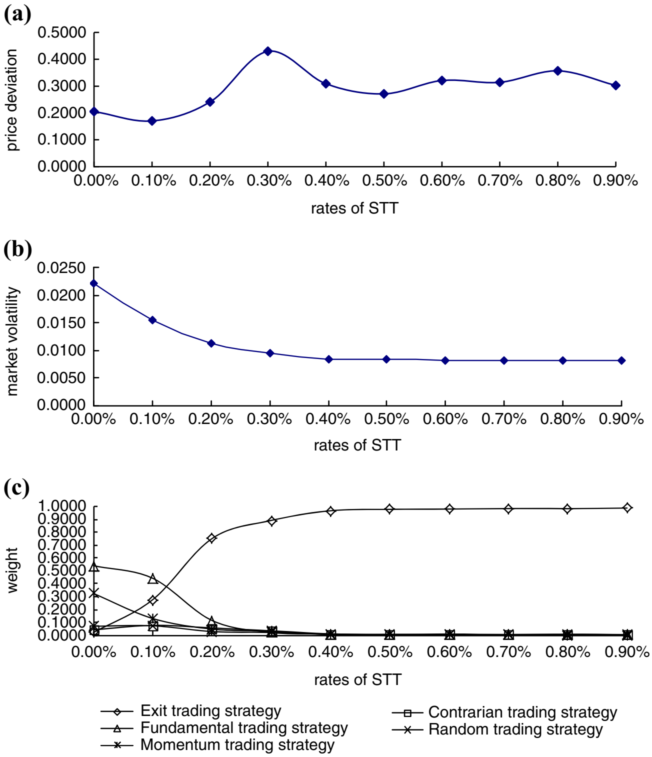


Figure 4.
The dynamics of the model with transaction taxes in the time domain

Notes: Volatility here is excessively high. (a) the absolute deviations between price and its fundamental value; (b) market volatilities; (c) Weights of investor trading rules. All statistics are estimated as averages over 50 simulation runs, each containing 1,500 observations

also show that the introduction of STTs significantly impair the activity of market. Even more, increasing transaction tax would decrease the investment interests of long-term fundamentalists, and exit-trading strategy becomes a dominant selection. Meanwhile, the margin of price deviation is enlarged, the efficiency of market pricing is weakened, which conforms the views of the anti-Tobin group supports. Therefore, it is proper to draw a conclusion that a STT is a double-edged sword, which should be used carefully to reach a delicate even fragile balance between market stability and efficiency.

4. Conclusion

Overall our investigations consistently show that transactions tax does contribute to stabilize markets by reducing market volatility, but its negative effects on market efficiency cannot be ignored at the same time. On the one hand, introducing an STT will raise transaction costs and deteriorate investors' expected profits as well as interests, finally bring market back into stabilization, which is in accordance with the original intention of Tobin Tax. Unfortunately, nothing comes for free. The adverse effects of a STT are not negligible. Specifically, it declines the activeness of the market, decreases the effectiveness of pricing mechanism and forces investors to leave the market. In conclusion, we suggest the administrations to adopt moderate tax rates (e.g. controlling the level of STT less than 0.2 percent suggested by our simulation work), which will not sacrifice too much market efficiency and vitality while making market less volatile.

However, our study has two limitations, one is that it only involves in one market and neglects the inter-dependence between different financial markets, and the other is our conclusions heavily rely on the model assumption about market microstructure as well as traders' behavior. Further study may aim at multi-markets analysis (e.g. Westerhoff and Dieci, 2006) and pay more attention to market conditions (see Song and Zhang, 2005) and market microstructure (see Rosenthal *et al.*, 2012) to gain comprehensive insights of the related issues.

References

Aliber, Z., Chowdhry, B. and Yan, S. (2003), "Some evidence that a tobin tax on foreign exchange transactions may increase volatility", *European Finance Review*, Vol. 7 No. 3, pp. 481-510.

Baltagi, B.H., Li, D. and Li, Q. (2006), "Transaction tax and stock market behavior: evidence from an emerging market", *Empirical Economics*, Vol. 1, pp. 39-408.

Campbell, J. and Froot, K. (1994), "International experiments with securities transaction taxes", in Rankel, J. (Ed.), *The Internationalization of Equity Markets*, University of Chicago Press, Chicago, IL, pp. 303-308.

Cincotti, S., Gardini, l. and Lux, T. (2008), "New advances in financial economics: heterogeneity and simulation", *Computational Economics*, Vol. 32, pp. 1-2.

De Bondt, W. and Thaler, R. (1985), "Does the stock market overreact?", *The Journal of Finance*, Vol. 40 No. 3, pp. 793-805.

Demary, M. (2008), "Who does a currency transaction tax harm more: short-term speculators or long-term investors?", *Journal of Economics and Statistics*, Vol. 228, pp. 228-250.

Demary, M. (2010), "Transaction taxes and traders with heterogeneous investment horizons in an agent-based financial market model", *Economics – The Open-Access, Open-Assessment E-Journal*, Vol. 4 No. 8, pp. 1-44.

Demary, M. (2011), "Transaction taxes, greed and risk aversion in an agent-based financial market model", *Journal of Economic Interaction and Coordination*, Vol. 6, pp. 1-28.

Eichengreen, B., Tobin, J. and Wyplosz, C. (1995), "Two cases for sand in the wheels of international finance", *Economic Journal*, Vol. 105, pp. 162-172.

Farmer, J.D. and Joshi, S. (2002), "The price dynamics of common trading strategies", *Journal of Economic Behavior & Organization*, Vol. 49 No. 2, pp. 149-171.

Habermeier, K. and Kirilenko, A.A. (2003), "Securities transaction taxes and financial markets", *IMF Staff Papers*, International Monetary Fund.

Hommes, C.H. (2006), "Heterogeneous agent models in economics and finance", in Tesfatsion, L. and Judd, K. (Eds), *Handbook of Computational Economics II*, Agent-based Computational Economics, North Holland, Amsterdam, pp. 1109-1186.

Jones, C.M. and Seguin, P.J. (1997), "Transaction costs and price volatility: evidence from commission deregulation", *American Economic Review*, Vol. 87 No. 4, pp. 728-737.

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

Lebaron, B. (2006), "Agent-based computational finance", in Tesfatsion, L. and Judd, K. (Eds), *Handbook of Computational Economics.II*, Agent-based Computational Economics, North Holland, Amsterdam, pp. 1187-1233.

Lo, A.W. and Heaton, J.C. (1995), "Securities transaction taxes: what would be their effects on financial markets and institutions?", in Hammond, S. (Ed.), *Securities Transactions Taxes*, Catalyst Institute, Chicago, IL.

Matheson, T. (2012), "Security transaction taxes: issues and evidence", *International Tax and Public Finance*, Vol. 19, pp. 884-912.

Rosenthal, D.W.R., Thomas, N.D.M., Wang, H. and Transaction Taxes in a Price Maker/Taker Market (2012), UIC College of Business Administration Research Paper No. 10-13; Midwest Finance Association 2013 Annual Meeting Paper, July 30, available at: http://ssrn.com/abstract = 1572648 or http://dx.doi.org/10.2139/ssrn.1572648

Shiller, R.J. (1989), *Market Volatility*, MIT Press, Cambridge, MA.

Shiller, R.J. (2002), "The irrationality of markets", *The Journal of Psychology and Financial Markets*, Vol. 3 No. 2, pp. 87-93.

Song, F. and Zhang, J. (2005), "Securities transaction tax and market volatility", *Economic Journal*, Vol. 115, pp. 1103-1120.

Stiglitz, J.E. (1989), "Using tax policy to curb speculative short-term trading", *Journal of Financial Services Research*, Vol. 3, pp. 101-115.

Summers, L.H. (1989), "When financial markets work too well: a cautious case for a securities transactions tax", *Journal of Financial Services Research*, Vol. 3, pp. 261-286.

Tobin, J. (1984), "On the efficiency of the financial system", *Lloyd's Bank Review*, Vol. 153, pp. 1-15.

Tobin, J.A. (1978), "Proposal for international monetary reform", *Eastern Economic Journal*, Vol. 4, pp. 153-159.

Umlauf, S.R. (1993), "Transaction taxes and the behavior of the Swedish stock market", *Journal of Financial Economics*, Vol. 33, pp. 227-240.

Westerhoff, F. (2003), "Heterogeneous traders and the tobin tax", *Journal of Evolutionary Economics*, Vol. 13 No. 1, pp. 53-70.

Westerhoff, F.H. (2008), "The use of agent-based financial market models to test the effectiveness of regulatory policies", *Journal of Economics and Statistics*, Vol. 228 Nos 2/3, pp. 195-227.

Westerhoff, F.H. and Dieci, R. (2006), "The effectiveness of Keynes-Tobin transaction taxes when heterogeneous agents can trade in different markets: a behavioral finance approach", *Journal of Economic Dynamics and Control*, Vol. 30 No. 2, pp. 293-322.

Zeeman, E.C. (1974), "On the unstable behaviour of stock exchange", *Journal of Mathematical Economics*, Vol. 1 No. 1, pp. 39-49.

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