MARGINS AND TRANSACTION TAXES IN AN INTRADAY CONTINUOUS DOUBLE AUCTION FUTURES MARKET

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ABSTRACT

Futures market price quotes and transaction prices are derived endogenously in an artificial market with bilateral trading in a continuous double auction. The market participants: hedgers, speculators and scalpers; have different strategies and reasons for trading futures. Risk neutral speculators with heterogeneous expectations try to maximize profit, while constrained by margin requirements and trading costs. Hedgers provide a fundamental price anchor and scalpers act as market makers. The futures exchange imposes real time gross settlement, margin requirements and a one-way transaction fee or tax on speculators. Despite a lack of individual rationality and well behaved demand functions, our model creates a bid-ask spread that, though turbulent, converges to the exogenous cost of trading for speculators and a mid-price that strongly detects the black box Walrasian price equilibrium. In a market with just speculators and hedgers, prices appear to be more "efficient" and trading volatility less when margins and transaction fees are high. Raising transaction costs increases the number of limit orders from speculators and this in turn helps stabilize the market price. However, trading volume and market liquidity declines when taxes or margins are increased. Including scalpers maintains trading volumes even in the predicament of high taxes and reduces mid-price kurtosis making the market price more resilient. However scalpers can also create a persistence in prices away from long-run fundamentals: scalpers increase trading volumes by supplying liquidity to either stabilizing or destabilizing speculators who are called on to make margin calls.

Keywords: Margins, Transaction Tax, Continuous Double Auction, Futures Market, Agent-based Model, Scalpers.

1 INTRODUCTION

Market microstructure emphasizes market design and the mechanics of trading. This paper simulates trading on a futures exchange. Unlike most papers in this genre, this paper ignores the role of information, learning and rationality, and investigates instead a market structure with diverse agents bound by trading rules or traditions. This is similar to the Gode and Sunder (1993) model of zero intelligence agents, where the budget constraint is critical to allocational efficiency. Despite its relative simplicity this preliminary study may provide insights for market design. Our project is to analyze the presence of liquidity, efficiency and stability at the aggregate level, without imposing exorbitant assumptions on micro behavior such as rationality, or the Arrow and Debreu (1954) restrictions.

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Most economic theories rest on the premise that aggregate relationships are stable over extended intervals of time. The creation of microfoundations to underlie these aggregate economic stylized facts have relied on maintaining the false hood that aggregates behave the same way as their component parts, and therefore attribute the behavior of the aggregate to that of some fictional representative agent (Shaikh, 2005).

In the next section we begin by describing futures trading on the floor of the exchange. There is a discussion on what is meant by liquidity, and how margin or tax policy might impact trader activity and market liquidity. section 3 explains the model. In opposition to most papers in this genre, this paper simplifies the trading process by removing information and learning from agent behavior. Speculator expectations are given at the outset and do not change. A continuous double auction (CDA) market is implemented with real time gross settlement (RTGS). Trading is derived from simplified but recognizable agent trading rules which may involve backward bending demand functions, leveraged trading, short selling, and asynchronous trading. In section 4 we experiment with some preliminary simulations and suggest ways that notions of liquidity and institutional detail such as margin requirements, transaction taxes, and RTGS might be evaluated. Our results find that despite individual instability, market stability is a common trait.

2 FUTURES MARKET TRADING

2.1 Open outcry

In an *open-outcry* futures market, as described by Silber (1984), all *bids* and *offers* must be announced publicly to the pit through the outcry of buy or sell orders. In particular, no prearranged trades are permitted on futures exchanges. Strict priority is kept, where the highest bid price and the lowest offer take precedence, and this is known as the *inside spread*. Lower bidders must keep silent when a higher bid is called out and higher offers are silenced when a lower offer is announced. Although simultaneous offers and simultaneous bids at the same price can occur. To increase the probability of execution a trader can raise his bid or lower his offer, and then other traders must remain silent. This rule is designed to insure best execution in the sense that sales occur at the highest bid price and purchases occur at the lowest offering, and all bids or offers do not live longer than the moment needed to make a transaction.

Ordinary traders (non-scalpers) usually look to *scalpers* to decide their action on the futures trading floor. Scalpers, also known as *locals* due to their exchange membership, are floor traders that trade on their own account and have low transaction costs and more flexible margin requirements than speculators. Like *dealers*, in bond or foreign exchange markets, scalpers regularly quote a bid price at which to buy, and an ask price at which to sell, *making a market* and thereby offering to complete orders quickly, typically at a price close to the last price, for those anxious to trade. By inserting this spread between the buy and sell the scalper thereby receives a profit for providing the service of *immediacy,* which is just one dimension of *liquidity*. They may also provide *depth* commensurate with the quantity they are willing to buy or sell. While scalpers typically provide liquidity, it is important to note that they can also "consume" liquidity when they liquidate or *offset* positions, by selling at the bid price or buying at the ask price. This reduction in liquidity may cause temporary instability (Schwartz 1988).

An ordinary trader (non-scalper) can either tender his own ask or bid quote which competes with the scalper, called *limit orders,* or he can accept the price currently quoted in the market, which would be called a *market order.* When a market participant accepts the market bid he is said to *hit* the bid. When he accepts the market ask he is said to *lift* the ask. The following example highlights the choices of a non-scalper who wants to buy contracts is taken from Silber (1984, p. 940). A commercial hedger, can instruct his *broker* (on the floor) to buy 50 contracts *at the market*, in which case the broker lifts the asks of others in the pit. Alternatively, the commercial hedger can try to buy more cheaply by instructing the floor broker to bid for 50 contracts at the prevailing bid price in the pit. In the first case, the *market order* uses the immediate execution services provided by the offerers in the pit (from scalpers or whoever) consuming liquidity. In the second case, the bid represented by the floor broker can be used by others to sell into, thereby providing liquidity.

Our study is partly to consider how effectively a financial market, with asynchronous trading, operates without intermediaries such as scalpers. Often the mismatch between buyers and sellers that typically exists at any given instant is resolved by some agents who are willing to play the role of *market maker* and provide *liquidity*.

2.2 The Bid-Ask Spread and Liquidity

The academic literature on market microstructure recognizes that the arrival of random traders to buy or sell is asynchronous, and market activities are temporally discrete. This literature treats such moment to moment aggregate exchange behavior as an important descriptive aspect of markets (Garman 1976) and has led to many interesting questions such as, how is market structure and the trading process related to the price process or the valuation of securities? What sort of trading arrangements maximize efficiency? How is information impounded in prices?

There is rarely a single price in microstructure analyses and the research into the CDA and the various prices derived from this: either quoted, averaged, or actually traded on, are components of the *bid-ask spread*. The size of the spread is an important dimension of *liquidity*. Modeling the spread is an extremely complex matter, given that the markets are composed of numerous *limit traders* (which include dealers and ordinary traders) embedded in a dynamic interactive environment. Such a system may best be modeled with agent based methodology.

The analytical bid-ask spread literature (Stoll 1978; and Ho and Stoll 1981) explains the demand for immediacy from the asynchronous arrival of random traders to buy or sell. It is often assumed that dealers participate in every trade, known as a *quote-driven market.* The behavior of the market maker or dealer is typically described as a trader who inserts a spread between the buy and sell and thereby receives a profit for providing the service of *immediacy* in what might otherwise be a fragmented market. This view of the market maker, as a provider of predictable immediacy, was first formalized by Demsetz (1968) and elaborated on by Garman (1976) and many others. It is generally accepted that the bid-ask spread is representative of the risks faced by the dealer due to inventory control and asymmetric information. When scalpers provide for market orders they profit from impatient traders but lose to traders more informed. It is usually concluded that given competition, the spread is due to the dealer's trading costs. This theory has formalized the idea of dealers as providers of liquidity and controllers of the size of the spread. Inventory control costs are assumed to be reasonably constant over time, while risks of asymmetric information are not (Engle and Lange 1997, p4). The size of the premium charged by *immediacy providers* to cover these expected costs determines the size of the spread and thereby the extent of illiquidity in the market.

Liquidity is often defined in many different ways. If the bid-ask spread reflects the price at which immediacy can be obtained by ordinary investors trading via market orders then a market is commonly thought of as perfectly liquid if trades can be executed with no cost (O'Hara 1997; Engle and Lange 1997). By this definition, a narrower spread means a more liquid market. This simplified characterization and measure of liquidity has recently gained popularity (see Flemming 2003), although many other definitions have long been debated.

Liquidity is usually said to have four dimensions, *immediacy, width, depth* and *resiliency*. *Immediacy* refers to how quickly trades can be arranged at a given cost. *Width* refers to the cost of doing a trade for a given size. *Depth* is the size of a trade for a given cost. *Resiliency* refers to how quickly prices revert to former levels after they change in response to large order flow imbalances (see Harris 2003, pp. 398-405).

Liquidity is often described as being supported by a particular group of traders. Market makers are considered the primary providers often endowed with the responsibility of balancing order flow: choosing prices that equate supply with demand. As a key participant in the price discovery process, the market maker acts as a matchmaker bringing public buyers and sellers together.[1]

Schwartz (1988) argues that too much emphasis has been made of market makers and their spread. While they may be needed in illiquid markets, they are not a necessity for liquidity: Schwartz emphasizes the resiliency dimension of liquidity, and argues that more attention should be paid to the manner in which ordinary traders also supply immediacy to each other and spreads may not simply be a phenomenon of the dealer/specialist spread (Cohen, Maier, Schwartz, and Whitcomb 1977). Ordinary limit order traders, also supply immediacy and compete to reduce market spreads with the scalpers (Cohen, Maier, Schwartz and Whitcomb 1979, p. 814). Schwartz (1988) warns that for market makers to stabilize a market they must commit capital or inventory risk, and this may become substantial. Injecting liquidity into a system to stabilize prices might also be just as quickly withdrawn at a later date if shortages are incurred or the market makers seek to rebalance their portfolios.

Alternatively, Bernstein (1987) and Black (1986) emphasize that *noise traders*, with their diverse opinions, help provide liquidity or *resiliency* of a market. Those who trade on noise allow others to trade on information. It is the noise traders that provide *depth, breadth* and *resiliency* to a market. At the same time however, noise traders add volatility to prices and push prices into over-evaluation or under-valuation, attracting information traders who push prices back to fundamentals. Hence noise trading actually puts noise into prices and prices are less efficient. "What's needed for a liquid market causes prices to be less efficient" (Black 1986, p. 32). Bernstein argues that this process leads to a curious paradox – "depth, breadth, and resiliency, in other words are not ends in themselves, but a means to induce information traders to trade. Efficient prices are possible only with noise traders creating inefficiencies by their buying and selling" (Bernstein 1987, p. 56). This is similar to the analogy of annealing: the market needs to be heated up and made more liquid, in order for the efficient price to be found. It is not true however, that liquidity is not an end in itself. With the segmentation of market roles

[1] See Stoll (1985) and Schwartz (1988) for further discussion and references on alternative views of dealers and scalpers.

into different agents, there are some, such as the managers of markets (for example, a central bank, a stock or futures exchange, or an investment bank managing a line of corporate bonds) who are only concerned with making their market liquid and leaving the price level or efficiency goal up to the informed speculators.

Harris (2003, pp.402-403) has different view from Bernstein (1987) and Black (1986). Along more traditional lines, he argues that liquidity is when prices return to their "fundamental value" and hence information is key in his description. He argues that it is the *value trader* that promotes resiliency. Value traders are the informed traders who collect as much information about fundamental values as is economically sensible. Value traders supply liquidity, under his notion, when prices differ substantially from their estimates of value, and trade in quite large sums that may be held over extended time periods. Harris argues that uninformed traders can have an impact on prices because dealers are passive traders and do not have an opinion about fundamentals, they are unable to distinguish between informed and uninformed traders;

However, Harris (2003, p.394) also argues that liquidity is best described as the object of bilateral search: buyers search for sellers, and sellers search for buyers. Liquidity is easiest to find when many people on both sides of the market are looking for it at the same time. This reiterates Berstein's and Black's analysis that it is noise traders that makes this search easier.

Value traders contribute to mean reversion only if they are all of the same opinion and *scalpers* provide immediacy but it may not necessarily be efficient. All these arguments depend on which traders have cash, or leverageability, on hand ready to modify their investment exposure at the cheapest possible price, through limit orders, thereby offering liquidity. Following on from Schwartz's contra-side orders, it would seem easier to not allocate liquidity to a group of traders (value, noise, intermediary), but rather state that market orders remove liquidity an limit orders provide liquidity. Included in the limit order category is the dealer bid and ask. We shall these different approaches may be considered in our model.

2.3 Margins and Transaction costs

In a futures market, transactions are promises rather than actual transfers of assets. Each promise to buy or sell a commodity at the future spot date is backed with collateral, which can be held as cash or treasury bills with the exchange (or broker). If it is held as treasury bills then it can earn a rate of return. A minimum margin (collateral) requirement is specified by the exchange to guarantee the fulfillment of each contract an agent holds whether long or short. The margin requirement is typically quoted as an absolute value per contract e.g. for a contract of 5000 bushels of July wheat on the CBOT the *initial margin* requirement is $1800 per contract. This amount is usually changed by the exchange during the contract's life: increased as the contract approaches maturity or when price volatility increases. A competitive exchange tries to minimize the margin requirement so that it just covers anticipated overnight price changes. For example, if price changes are thought to have even a small chance of moving 10 percent, then the exchange would like to make sure that traders have margin holdings of at least 10 percent of the contract value, ensuring contract fulfillment. A transaction fee is often imposed on round trip transactions. Brokers, exchanges or government can institute this as a as a tax.

Typically thought of as liquidity augmenting, policies to reduce margin requirements and transaction costs are advocated because they increase the amount of trading in a market which is often thought to reflect liquidity and reduce price volatility. In opposition, there have been a number of economists who argue that excessive trading can increase volatility. They wish to remove noise trading by raising margin requirements (Shiller 2000, Schlesinger 2000) or imposing a transaction tax (Tobin 1974, Pollin et al 2001) to reduce *excessive speculation* and price volatility in foreign exchange, equity, and futures markets. There many debates on whether such policies would increase or decrease extreme price volatility (fat tails in the price distribution). Critics argue that taxes would only increase volatility and that it cannot stop large price movements from occurring (Davidson 1997). Insights might be garnered by an agent-based modeling approach to these policy debates.

3 AGENT-BASED MODEL OF A FUTURES MARKET

3.1 Model Environment

We present a model of speculators, scalpers and hedgers in a futures trading pit with *open-outcry* and a continuous double auction trading mechanism. In this simplified model, all trader expectations, though heterogeneous, remain constant to place focus on the trading mechanism and the impact of trader budget constraints. This is a partial equilibrium model with two markets: a speculative futures market for grain and a residual money market. The price of money is normalized to 1 and agents operate on their budget constraint which is a function of their wealth, transaction costs, and futures contract margin requirements. There is no restriction on short selling. RTGS is implemented such that traders settle with each other and the exchange at their time of trade, rather than waiting until the end of the day.

Margins are implemented in this paper in a simplified manner, though still relevant to modern market design. Firstly, we mark-to-market trader positions using RTGS. Thus, instead of using the close of day *settlement price* to calculate margin calls, settlement is adjusted continuously throughout the day and the settlement price used to calculate margin calls is the average of the bid and ask price, or mid-price. This means that profits and losses transfer hands between the exchange and the traders continuously, removing the risk of accumulated losses and trader default. This payment transfer is called the *variation margin*.

Secondly, the model analytically simplifies the margin calculation by making the *initial margin* and *maintenance margin* the same, and specifying the margin requirement as a fixed percentage of the contract value rather than an absolute dollar value per contract. By using a margin requirement that changes with the percentage change in prices, we get closer to the essence of what the exchange considers in setting the margin.

Given these two margin features our model offers considerable price and quantity feedback opportunities. While for an individual high risk speculative trader, marking to market is a cautionary act and reduces counterparty risk, it can also result in a volatile market price the higher the settlement frequency (Farmer et al 2004). If traders are on their budget constraints, then they will liquidate some of their position when prices move against them to stay within their margin requirements, and this creates backward bending demand functions - introduced in section 3.2.

Each type of trader has their own rules for trading. *Speculators* are risk neutral and differ only in their expectation of what the futures price should be and their wealth. Expectations of the next period futures contract price stays constant during the trading period. Being risk neutral, speculators are typically at the corner solutions of their budget constraint, maximizing their futures position (long or short) at every chance they get to trade. There is a one-way fee imposed by the exchange, charged as a percentage of each transaction at the point of sale or purchase. The contract size is perfectly divisible and prices are always non-negative. Speculators are required to hold a minimum amount of cash in their margin account which is a percentage of the futures contract value. To safeguard contract fulfillment the exchange carries out real time gross settlement (RTGS) with *variation margins* imposed on every transaction.

Scalpers are members of the exchange and operate on the floor of the exchange without paying a trading fee. They do not have an opinion on the fundamental price and instead try to buy as low, and sell as high, as they can. They want to maximize the turnover of buys and sells, while minimizing their inventory holding. Scalpers prefer to place limit orders (quotes) and buy at their bid quote and sell at their ask quote. Scalper activity assists in balancing order flow over the long run, which does promote price efficiency but it could create price instability in our bilateral CDA when either they offer liquidity to so-called noise traders, or when they liquidate their own inventory holdings.

Hedgers only play a limited role in setting up the fundamental demand and supply of contracts in the market. There are only 2 representative hedgers, one going long the other going short, the difference being the net hedge. They only place market orders to fill their desired contract positions. The quantity of contracts desired is exogenous to the model and do not change. Once their futures position is attained they stop trading and together leave a net excess demand or supply for the rest of the traders in the market to sort out.

Within the CDA, speculators and scalpers (if included) are selected for a sequence of bilateral trading through random non-replacement in each round so that every trader has an equal chance of trading. The hedgers are placed last in this sequence which represents one round. The intra-day period of futures trading has several rounds of quoting or transacting, at the bid or ask price. Trades and transaction prices are registered at each time τ.

3.2 Speculator's Demand Function

In our model with leveraged speculation we use κ to represent the limit on how much larger a speculator's futures position, price times number of contracts ($p_\tau x_\tau$) can be compared to a trader's wealth m_τ. For example, if $\kappa = 4$ then a trader can have up to 4 times their wealth dedicated to a long or short futures position. In other words the margin requirement is 25 percent, $1/\kappa = 0.25$. The collateral kept in the margin account by speculator i is held as either Treasury bills or money, represented here as m_t^i. Money held must be greater than the margin requirement, $m_t^i \geq p_t x_t^i / \kappa$ for the current futures position, at all times (to the extent that trading allows). There will be several transaction prices through out the day which represent a trade at either a quoted bid p_t^b or a quoted ask p_t^a. If there is not enough collateral in the margin account to meet the margin requirement then speculator i will have to liquidate their position with an offset purchase or sale at their next turn to trade.

The futures position x_τ at price p_τ is taken on by the speculator as a contract at time τ to sell or buy x units of the underlying commodity at price p_τ on the spot or maturity date of the futures contract. Since our speculator does not intend on making delivery on this contract, the purpose of holding this position is to flip the position and profit on price changes. Based on price expectations $p^{i,\ominus}$ of the next transaction price $p_{\tau+1}$, speculator i will decide to go either long or short in futures. If the expected short-term gain does not compensate the cost of trading over the next period:

$$(p^{\ominus}_{\tau} - p_{\tau})\, x_{\tau} \le \varpi\, p_{\tau}\, |\, (x_{\tau} - x_{\tau-1})\, |$$

then the speculator will hold his current position instead of trading. The trader is myopic and on opening a position there is no consideration of costs incurred for reversing the position.

Each speculator is risk neutral and simply maximizes expected wealth π:

$$\pi^{e}_{t+1} = \left(p^{\theta} - p_{t}\right)x_{t} + m_{t}$$

The speculator's demand curve is derived in the appendix via a linear programming solution. In summary, speculator i's demand for futures in each period τ is a slightly simplified version from Ussher (2004):

$$x^{i}_{t}\left(p_{t}; x^{i}_{t-1}, m_{t-1}, p_{t-1}, p^{i,\theta}, \kappa, \varpi,\right)$$

where:

p_t	Intra day futures market transaction price at time τ
x^{i}_{t-1}	Previous contract position
m^{i}_{t-1}	Previous cash position in margin account following last transaction
$p^{i,\theta}_{t}$	Price expectation $p^{\ominus}$ of the next futures price $p_{\tau+1}$
$1/\kappa$	Margin requirement as a percentage of futures position value
ϖ	Percentage transaction tax on a one-way trade. Paid each way.

A futures demand curve is usually represented as a smooth downward sloping line from the top of quadrant II to the bottom of quadrant I in the two dimensional R^2 space in Figure 1. Our model produces a non-linear demand function due to inherent corner solutions from wealth constraints and the regulatory setting of margin limits $1/\kappa$, transaction costs and real time gross settlement.

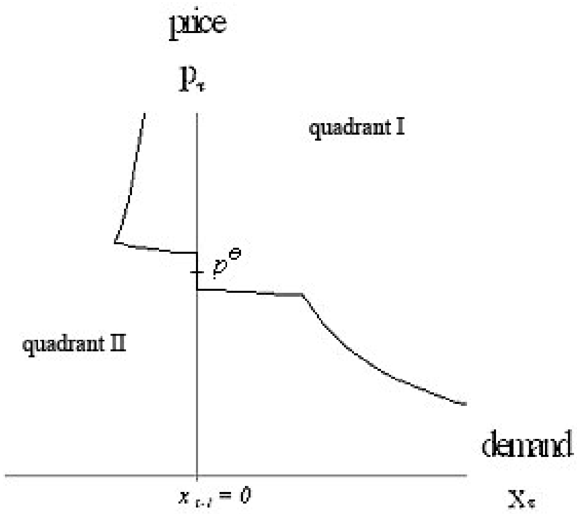
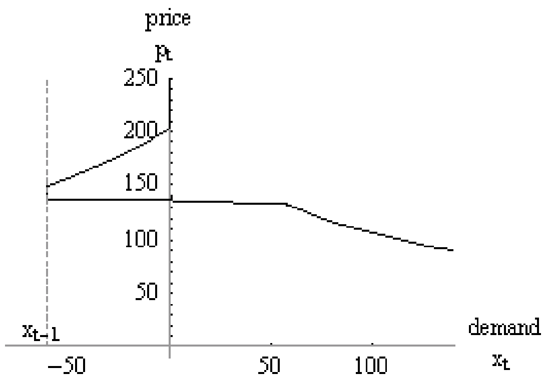
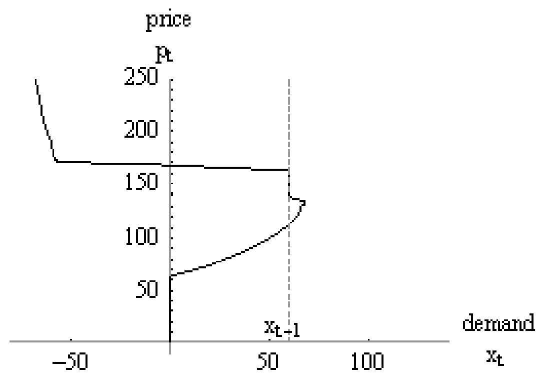


FIGURE 1 A speculator's demand for futures x_τ as a function of p_τ, with a past zero position $x_{\tau-1}$, and price expectations of $p^{\ominus}$.

Each risk-neutral speculator maximizes the next period's expected wealth by holding money as collateral and buying or selling (going long or short in) futures. The decision to buy or sell futures depends on whether the speculator expects prices to rise or fall, respectively. There is no restriction or disincentive to *short selling* – selling commodities that one doesn't own. The trader will only trade when price expectations p^{θ} are far enough away from the actual prices p_{τ} to pay for the one-way transaction costs. Figure 1 has a zero contract position held over from last period. If a speculator currently has a futures position then margin calls can lead to forced liquidation of the position when prices move against expectations. The possibility of a backward bending demand function, as in Figure 2, is due to collateral *px*, which underlies demand for *x*, being priced in the same market.



Speculator is short futures $x_{\tau-1} = -60$



Speculator is long futures $x_{\tau-1} = +60$

FIGURE 2 A Speculator's Demand Curve with either a short or long position: $m_{\tau-1}$=5000, p^{θ} = 150, and κ=2 for each graph.

The speculator will sell (buy) futures if he expects the price to fall (rise) when the slope of the demand function is positive. The demand function has a negative slope when either purchasing power is declining from higher futures prices, or when collateral is devalued and the speculator must liquidate part of their position to maintain the margin requirement.

At each τ the variation margin is calculated and net wealth adjusted. The mid-price p^m is the average of the bid quote p^b and ask quote p^a:

$$p^m = (p^a + p^b)/2$$

Using the mid-price, the profit or loss is calculated with price changes and paid from the losing agent to the winning agent via the exchange equivalent to

$$\left(p_t^m - p_{t-1}^m\right)x_{t-1}^i$$

Each speculator estimates their net wealth at each τ given prices (p^a, p^b, p^m) which determines their decision: how many futures contracts to buy or sell to maximize expected wealth, while at the same time meeting their margin requirement which is κ times net wealth. The mid-price is used in accounting for net wealth every period, as long as a position is held. [2]

3.3 Bidding and Trading Process

Central to our model is the auction process that simulates the open-outcry on the floor of an exchange, leading to transactions and thus transaction prices. It is a tâtonnement mechanism where both bid and ask prices adjust and out of equilibrium trades take place when an agent agrees to sell contracts to another agent who is bidding for them. Or another agent decides to buy contracts from the agent who is asking for them. This process of quoting and trading is repeated many times, to give every market participant the chance to quote and trade several times and fill their orders. No new information is brought into this process - expectations remain constant.[3]

The competitive bidding algorithm presented here is drawn from several sources. The manner in which speculators compete and how their price expectations interact with the bid-ask spread during the bidding process comes from Chan, LeBaron, Lo and Poggio (1998), (hereinafter known as CLLP) and Yang 2002. An important modification to their model, apart from keeping expectations constant, is our distinction of risk neutral speculators with collateral constraints and transaction costs. In addition, we have drawn on another algorithm derived from Silber (1984), emphasizing inventory control and non-competitive bidding by our scalpers. Hedgers act similarly to speculators but only place market orders and hence do not compete in the bid-ask spread. These agents are used to represent fundamental supply and demand.

This asynchronous bilateral bidding process allows 2 or 3 traders to participate at any one time – either offering or bettering quotations, or 2 of the traders carry out an exchange. Agents take turns in entering into the inter-dealer market to either quote, transact, or exit. A round is completed when all agents have participated once, with the hedgers coming last. This is repeated, in a random sequence, for over fifty rounds with the goal of testing the efficiency of the price mechanism and the convergence to an equilibrium where aggregate demand equals aggregate supply.

3.4 Auction Algorithm for the Speculator

Half of the bid-ask spread is often thought as a measure of the cost of executing a market order (the difference between the mid-point price and the payment price). We shall represent this price difference by lower case *s*. The size of this spread is actually endogenous to the bilateral

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[2] On the initial purchase of a market order the trader must pay a *variation margin* of $\left(p_t^m - p_{t-1}^m\right)\left(x_t^i - x_{t-1}^i\right)$. Important in this calculation of variation margin is that we keep the distinction between those that profit by buying at the bid or selling at the ask, versus those who are considered impatient and sell at the ask or buy at the bid. When a contract is bought and $\left(x_t^i - x_{t-1}^i\right) > 0$, if it is bought at the bid with a *limit order* then the variation margin is positive $\left(p_t^m - p_t\right) > 0$. If however it is bought at the ask with a *market order* then the variation margin is negative $\left(p_t^m - p_t\right) < 0$. This results in a transfer of wealth from the trader who is willing to pay for *immediacy* to the trader who gets paid for providing liquidity and *making the market*. The maximization of expected wealth by the speculator only takes into account the expected change in the trade price $\left(p^\theta - p_t\right)$ without anticipating whether the transaction is by market order or limit order.

[3] In another paper by the author expectations do change after a specified number of intra-day trading rounds with expectations constant.

trading process. In our model, speculator *i*'s reserve price is their expected price $p^{i,\theta}$ plus the one-way transaction tax, ϖp_τ.

At times when there is no bid or ask, a speculator will announce his own noncompetitive limit order based on expectations $(1 \pm S\,\varpi)\,p^{i,\theta}$. In this case, *S* is a percentage of the transaction fee. If *S* is greater than 100 percent then the new limit order will guarantee that a new hit or bid occurs with a demand different from zero.

We shall present the speculator algorithm with three traders: agent *k* has the best bid to date, agent *j* has the best ask to date, and agent *i* is the new entrant that makes a trade choice under the following four scenarios. Agents *j* and *k* are offering the best ask and bid quote to date, respectively, and are scalpers or speculators. Agent *i* represents a speculator that enters the market and witnesses the current bid-ask spread. Speculators attempt to profit by positioning themselves each period to maximize short run profit over every single period τ.

Scenario 1. The bid, $p_t^{j,a}$ and ask, $p_t^{k,b}$, currently exist with non-zero offers, at time τ

1. If $p^{i,\theta} > p_t^{j,a}$ speculator *i* will post a market order and buy at this ask price – lift the ask quote.
2. If $p^{i,\theta} < p_t^{k,b}$, speculator *i* will post a market order and sell at this bid price – hit the bid quote.
3. If $p_t^{k,b} < p^{i,\theta} < p_t^{j,a}$ and $< \left(p_t^{k,b} + p_t^{j,a}\right)/2$, speculator *i* will post a sell limit order at a price of $(1+ S\,\varpi)\,p^{i,\theta}$ and thus quote his own ask, replacing agent *j*
4. If $p_t^{k,b} < p^{i,\theta} < p_t^{j,a}$ and $> \left(p_t^{k,b} + p_t^{j,a}\right)/2$, speculator *i* will post a buy limit order at a price of $(1+ S\,\varpi)\,p^{i,\theta}$, and thus quote his own bid, replacing agent *k*

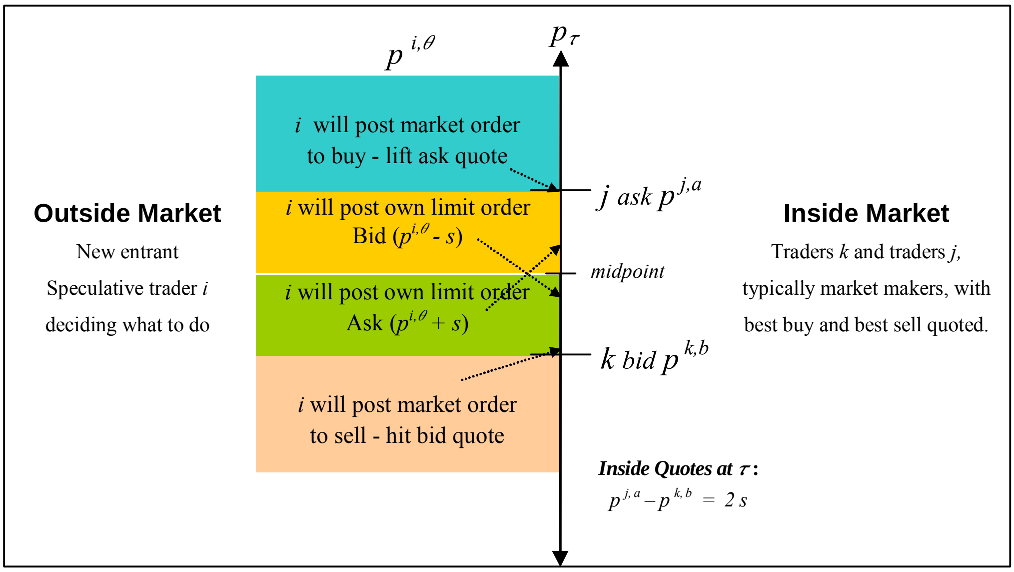


FIGURE 3 Scenario 1: Both competitive quotes, bid and ask, exist in the market place prior to new entrant.

Scenario 2. Only the best ask, $p_t^{j,a}$, exists, that is, at $p_t^{k,b}$ demand is zero $\left(x_t^k - x_{t-1}^k\right) \le 0$
1. If, $p^{i,\theta} > p_t^{j,a}$ speculator *i* will post a market order, buy at this ask price.
2. If $p^{i,\theta} < p_t^{j,a}$, speculator *i* will post a buy limit order $p_t^{i,b}$ at a price of $(1- S\,\varpi)\,p^{i,\theta}$, but only if excess demand at this price is $\left(x_t^i - x_{t-1}^i\right) > 0$

Scenario 3. Only the best bid, $p_t^{k,b}$ exists, that is, at $p_t^{j,a}$ demand is zero $\left(x_t^j - x_{t-1}^j\right) \geq 0$
1. If $p^{i,\theta} < p_t^{k,b}$, speculator *i* will post a market order and sell at this bid price;
2. If $p^{i,\theta} > p_t^{k,b}$, speculator *i* will post a sell limit order $p_t^{i,a}$ at a price of (1+ S ϖ) $p^{i,\theta}$, but only if excess demand at this price is $\left(x_t^i - x_{t-1}^i\right) < 0$

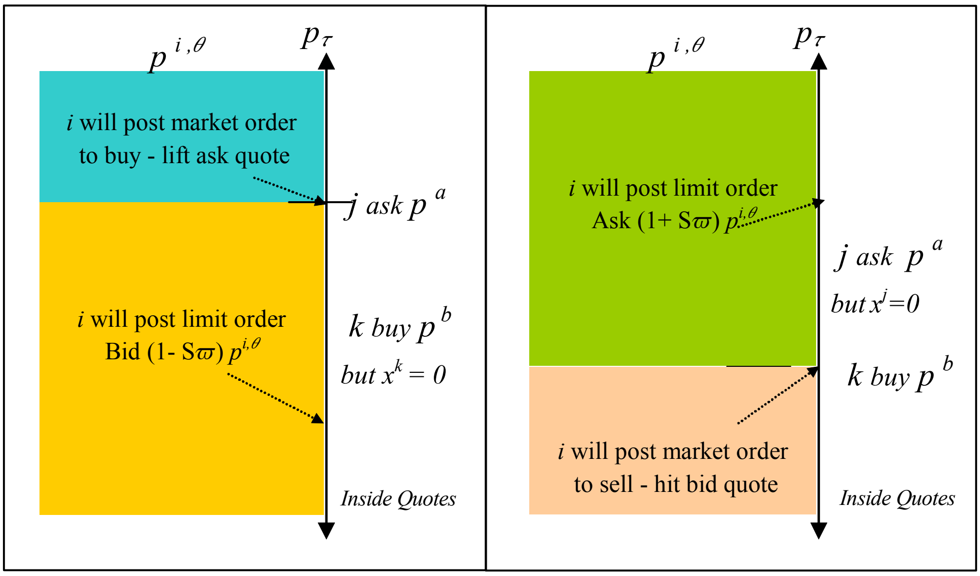


FIGURE 3 Scenario 2: An ask but no bid exists prior to new entrant; Scenario 3: A bid but no ask exists prior to new entrant.

Scenario 4. If no bid or ask exists, that is at $p_t^{j,a}$, $\left(x_t^j - x_{t-1}^j\right) \geq 0$ and at $p_t^{k,b}$, $\left(x_t^k - x_{t-1}^k\right) \leq 0$
1. The new entrant speculator will post both or either a buy and/or a sell limit order at (1- S ϖ) $p^{i,\theta}$ and/or (1+ S ϖ) $p^{i,\theta}$ respectively, as long as their bid is quoted for a buy of greater than zero contracts, and the ask is to sell greater than zero contracts. If this is not the case then the current bid ask remains, even though both traders have zero demand, and entrant *i* exits to join the queue to trade again later.

In our model, under scenario 2 (3) the speculator tendering the best bid (ask) might have had prices move against him (for example, if he is long (short) and prices fall (rise)). They may remain offering a bid (ask) price to buy (sell) but at a quantity of zero. Now he wants to offset his position and sell (buy) so that excess demand is less (greater) than zero.

Scenario 2: $\left(x_t^k\left[p_t^{k,b}\right] - x_{t-1}^k\right) \leq 0$ where x_t^k is a function of $p_t^{k,b}$

Scenario 3: $\left(x_t^j\left(p_t^{j,a}\right) - x_{t-1}^j\right) \geq 0$ where x_t^j is a function of $p_t^{j,a}$

Effectively under scenario 2 (3) agent *k* (*j*) falls silent and will eventually be replaced by a new entrant as long as the new entrants $p^{i,\theta} < p_t^{j,a}$ ($p^{i,\theta} > p_t^{k,b}$)and $\left(x_t^i\left[(1+S\varpi)p_t^{i,\theta}\right] - x_{t-1}^i\right) > 0$ ($\left(x_t^i\left[(1-S\varpi)p_t^{i,\theta}\right] - x_{t-1}^i\right) < 0$)otherwise agent *k* (*j*) will remain. Only when agent *k* (*j*) is replaced and exits the market will he be given the chance to satisfy their margin requirement by liquidating their position with a market order in turn in the random trading round.

This model considerably changes the CLLP rules, which emphasizes the manner in which price formation feeds back into the market by agents updating their expectations, to one where price formation feeds back into the market via quantity constraints, margin requirements and inventory control. This model allows for leveraged trading, short selling and makes the method of settlement a central variable of the model.

3.5 Auction Algorithm for the Scalper

In addition to speculators, we have a group of *scalpers* that sometimes participate in the futures open-outcry. The scalper algorithm is a simplified version of one stated in Smidt (1985). The objective is to buy at the bid and sell at the ask, maximizing a profit equal to the turnaround of inventory times the spread, while minimizing inventory risk with a very simplified control mechanism. There is a maximum net inventory ceiling *K* for each scalper. Netting out the long and short trades by a single agent consolidates the inventory x_T. Scalper inventory must be:

$$-K \le x_t^n \le K \quad \text{for scalper } n$$

In actual markets *K* is often as small as one contract and could be different for different scalpers. In our model all scalpers have the same *K=10*. When a scalper enters the trading floor from the random sequence, if their inventory is less than their maximum limit *K*, they always have the right to replace any agent in the *inter-dealer* market by simply matching their quoted bid and ask. This is in contrast to speculators who must offer a better price to replace the agents in the inter-dealer market. If, however, the scalper's inventory is on his limit then the scalper will place a market order to off-load all inventory, if possible. The scalper algorithm is one of simple inventory control:

New Entrant Scalper n:
1. If $-K < x_t^n < K$ replace current market makers and quote both bid and ask at the current quotations $p_t^{k,b}$ and $p_t^{j,a}$, for quantity $K - x_t^n$ buy and $-K - x_t^n$ sell.
2. If short and $x_t^n \le -K$ hit market bid for a maximum $-x_t^n$, post no quotes
3. If long and $x_t^n \ge K$ lift market ask for maximum $-x_t^n$, post no quotes

Scalpers will try to charge as high a price as possible when selling, and as low a price as possible when buying, while still competing with other traders to make a sale or purchase. Only the highest buy (bid) and lowest sell (ask) are heard in the trading pit. All other non-competitive quotes must remain silent. Since speculators must compete on price; only speculators are able to narrow the inside market bid-ask spread. Scalpers balance market order flow by using the *inter-dealer market* to offset their own inventory excesses, taking a loss in order to liquidate an unbalanced inventory position forces other inter-dealer scalpers to also liquidate and this dries up liquidity in the market until prices are modified.

The dealer inventory control model outlined here, where a scalper will choose to make a market order rather than change his limit order prices, is in contrast to most accepted inventory control models such as Garman (1976) and Amihud and Mendelson (1980). These authors present dealers as changing their bid and ask to induce an imbalance of incoming orders, to reduce inventory. Hasbrouck (2003) questions this latter model and claims that as a general rule most empirical analysis of inventory control refutes this method of changing the quote for inventory control. He argues that a dealer that would pursue the hypothesized mechanism would be signaling to the world at large his desire to buy or sell. This puts him at a competitive disadvantage (Ibid 2003, p. 78). Our simplified mechanism does not touch on information signaling, yet it does avoid this specific criticism.

3.6 Auction Algorithm for a Representative Hedger

Hedgers are only concerned about filling their expected sales or purchases at the spot date via market orders in futures. They always come last in each round of the random sequence of speculators and scalpers.

Hedger Scenario:
1. Purchaser of commodity at spot, agent q will lift the ask, $p_t^{j,a}$, for maximum ask quote quantity, until market buy order is filled $x_t^q = x^{q*}$
2. Seller of commodity at spot, agent r will hit the bid, $p_t^{k,b}$, for maximum bid quote quantity, until market sell order is filled $x_t^r = x^{r*}$

Since speculators and scalpers not offer large size contract lots it may take a number of rounds for our hedgers to finalize their purchases or sales. The hedgers contribute so called *fundamentals* to our speculative market.

4 MARKET STRUCTURE AND SIMULATION OF INTRA-DAY TRADING

In creating a market that consists of highly speculative individual agents that are inherently unstable, we wish to discover how robust and stable our market is given the regulatory framework of transaction taxes and margin requirements. With no change in expectations we focus our analysis on the impact of trading volatility on price formation. This is quite separate from the volatility that comes from expectations and information issues. We will consider how efficient trading is in converging to a stable equilibrium price that equates aggregate supply and demand.

The series of steps in our market begins with a random ordering of 60 speculative agents and (when included) 10 scalpers. The 2 representative hedgers come last in this sequence which once completed is called a trading round. Speculators have equal endowments and heterogeneous expectations taken from a symmetric distribution with mean $p^{\theta} = 150$. Speculators come together, along with hedgers and scalpers, in bilateral trades to create a CDA.

Two randomly selected traders begin with market quotes set at $p_0^b = 100 : p_0^a = 110$. A new entrant, randomly selected from the remaining traders (not a hedger), enters the floor to either accept or better the prices quoted. If a bid or ask is accepted a trade is done and a transaction price p_1 occurs for say a market order by the new entrant. If instead, the entrant replaces a bid or ask or both then a new set of quotations $p_1^b : p_1^a$ (bid:ask) is created with no transaction price. A sequence of quotes, and transaction prices, is generated during the trading round, with only transaction prices and volumes registered. Repeating the round, drawing a new random sequence of speculators and scalpers each time, creates a trading session.[4] This trading sequence is summarized below:

[4] In this paper we stop at this point. But if one session was considered one period of constant expectations, in between the updating of expectations, then strung together such trading sessions could be seen as a day of trading.

4.1 Trading Sequence

1. Speculators are initialized with initial wealth and random price expectations with mean 150. Two randomly selected speculator or scalper begin with initial quotes of $p_0^b = 100 : p_0^a = 110$ and their respective buy and sell quantities (which may be zero) given their expectations.
2. Determine the random sequence of speculators and scalpers to enter the market with non-replacement, with hedgers coming last.
3. With one or two agents quoting a bid-ask spread, the new entrant can either submit a new bid or ask, accept the existing bid or ask, or hold (pass).
4. A transaction occurs when the existing bid or ask orders are accepted and the transaction price is recorded accordingly. The transaction is the minimum of the quantities proposed for exchange by each bilateral trader.
5. At each point, mid-point prices are used to calculate speculator budget constraints in real-time. Based on the past transaction price, each agent's wealth is updated taking account of all margin calls (profits and losses).
6. Repeat (3)-(5) for n times, n = number of traders (one round).
7. Repeat (2)-(6) for N times, N = number of rounds.
8. Final market price is recorded as the last transaction price for this trading session.

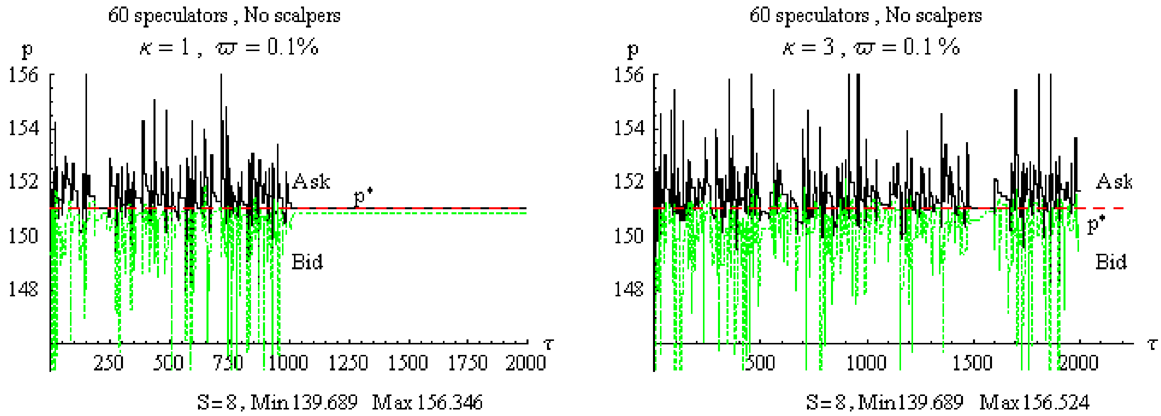
The CDA bilateral search and trade algorithm is similar to a repetitive annealing process where the market is heated up through turbulent trading when margins are low. This might be representative of a hot or liquid market, and this is warranted in order for the equilibrium point to be found. If traders become satisfied with the price and reduce their trading then the market cools and converges to its fixed price or the efficient market price. But once it cools the market becomes brittle and a single trader can disrupt the price with a new quote $(1 \pm S\,\varpi)\, p^{i,\theta}$ causing a credit crunch and trading volume increases. The market heats up again and the process is repeated.

4.2 Simulation for 60 Speculators and No Scalpers.

We begin by simulating a continuous double auction with just speculators and hedgers to consider how speculators alone can effectively replace formal market intermediaries, as suggested by Schwartz and Economides (1995). We use 60 speculators with the same wealth and randomly designated expectations drawn from with three different normal distributions: all have a population mean of 150, and a standard deviation, σ, of either 1, 2, or 5. These 60 agents together have a sample mean of *150.4*, a standard deviation of 2.7, and a kurtosis measure of 4.7. These same expectations were used in each simulation. The following parameter trials included a tax of either $\varpi = \{0.1\%, 0.5\%\}$ on each one-way transaction and a margin requirement of either $1/\kappa = \{100\%, 33\%, 25\%\}$. All plots below are by transaction dates hence competitive quote changes where the bid-ask spread is be narrowed through new limit orders do not show up. Only when a market order or purchase occurs are the bid-ask, midpoint and transaction prices recorded at time τ.

Figure 4 shows bid, ask and p* which is the Walrasian equilibrium price solution at time $\tau = 0$, given expectations, wealth, and the net hedge. The large swings outwards by the bid-ask spread are due to the exogenous prices $(1 \pm S\,\varpi)\, p^{i,\theta}$ that new entrants get to yell out a limit order when one of the inter-spread dealers is offering a zero quantity bid or ask which they want.

In these simulation S =8. We also used S=1.5 which resulted in the same average price except that the market was very slow to equate demand and supply.



—— Ask - - - Bid - - - p* Walrasian Equilibrium at $\tau = 0$

FIGURE 4 Bid-Ask quotations at each transaction. Margin requirements: 100% vs 33 %.

As in all our simulations the CDA bid-ask spread detected the Walrasian equilibrium price during the life or our trading examples. Given the relative symmetry in our wealth weighted market expectations and the small net hedge in the market ($x^{r^*} - x^{q^*} = 5$) this may not be as significant as it might seem, and is worthy of further investigations. There was a narrowing of the spread as speculators competed with each other, but it never got smaller than the tax, ϖp_τ, per unit x. When aggregate demand as a function of the ask was effectively equal to aggregated supply as a function of the bid then the bid ask spread and mid-point price "flatlined," as in figure 4 for κ=1 or 100% collateral. In this case order flow is kept balanced in aggregate as most speculators stopped trading and only very small trades occurred between 2 active traders post τ=1000, as seen in Figure 5. Their expectations were very close to p*(1± ϖ).

For κ=1 the futures position of traders, shown in Figure 5 as being either long or short and as a proportion of wealth, are relatively steady. Trades are small and most agents remain in the same position. This is quite different when the margin requirement is reduced to 33%, κ=3, in Figures 4 and 5. More trading is taking place and a larger number of traders remain below their leveraged limit. Those agents with the most extreme price expectations will spend most of their trading time on their limit, more so than those with 'more accurate' price expectations – closer to p^*.

While reducing the margin requirement stimulated trade activity[5] it did nothing to the average, or standard deviation, of the mid-point price (both simulations approximated mean 151 and sd 1). The lower margin did however reduce kurtosis of the mid-point price from 11 to 4 (during τ=100 through to τ=1000). This might indicate that lower margins and more trading makes the market price more efficient in the sense that the price distribution has smaller tails.

[5] For trading points τ=100 through to τ=1000, the average trade when κ=1 was 0.08x contracts. This compares to an average trade volume of 6x contracts when the margin is reduced to 33%, κ=3.

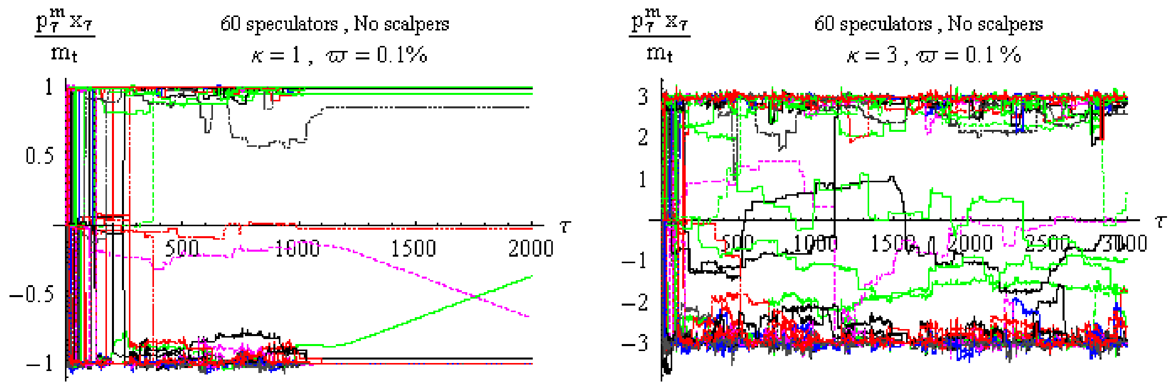


FIGURE 5 Leverage position by each speculator over time. Long is positively leveraged and short is negatively leveraged. Margin requirements: 100% vs 33 %.

Within our simple model there is some support for Friedman's (1953) Darwinian suggestion that speculation is efficient because noise traders die out and fundamental traders prosper. This argument is often used in policy circles for the reduction of margin requirements. This assumes that there is only one right price, and our model confirms that those traders with expectations furthest away from p* do lose money trading. Despite symmetric expectations about mean 150, the aggregate income for the group of 20 speculators with a population standard deviation of σ =5, is shown to decline faster in the lower margin environment as shown in Figure 6. The agents with the least noise (smallest dispersion) of expectations around the population mean have greater capital gains because they are more likely, as a group, to be paid for providing immediacy (placing limit orders rather than market orders) and this compensates their cost of trading.

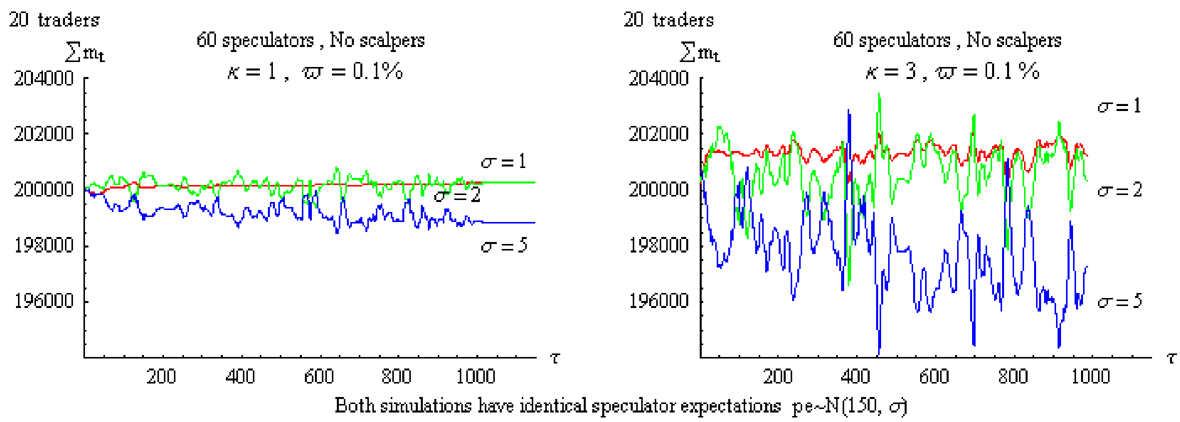


FIGURE 6 Aggregated wealth of each group of 20 speculators, smoothed with a 15 period moving average. Margin requirements: 100% vs 33 %.

The faster decline in wealth of the noisiest pool of speculators for κ=3 may have helped to consolidate the price series for the lower kurtosis of the mid-point price. The transaction price did have a slightly higher standard deviation of 1.65 for κ=3, instead of 1.15 for κ=1. There is more activity in the second market: with low margins, κ=3, the market had 63 rounds of trading for the first 1000 transaction prices; in the high margin market where κ=1, fewer traders were involved in transacting which meant that 1000 transactions were accomplished in 84 rounds.

Trading volume and trade activity is higher in the higher leveraged market due to the greater impact price changes and margin calls have on changing wealth - possibly for a more consolidated price series.

The narrowing of the spread to the cost of transacting ϖp occurs by the marginal speculator with the lowest price expectation greater than $p^a(1+\varpi)$, which can still sell at the lowest ask; and that speculator with the highest price expectation below $p^a(1-\varpi)$, that can still buy at the highest bid. Both speculators will have their expectations very close together, and are willing to quote a bid or ask that still compensates them for their costs of transacting. This is why the spread does not (typically) narrow below ϖ. This spread only remains constant while these marginal traders are willing to increase their position at the given market prices. If they choose to no longer trade, then prices will change and a new convergence to a possibly different equilibrium will occur.

We experimented with lowering the margin requirement and raising the transaction costs of trading. Anecdotal evidence shows that lowering the margin to 25% or κ=4, may increase kurtosis, e.g. our mid-point price for (κ=4, ϖ=0.1%) increased to 20. By increasing the costs of transacting from 0.1% to 0.5% we again reduce trading activity, despite a low margin requirement. Trading is much more orderly in the sense that there is less volume traded.[6] It is hard to compare the kurtosis of prices given the two different tax regimes. In Figure 7 we can see that the bid-ask spread is still ϖp and tends to flat line more often with the tax increase, and in the second graph, speculators have relatively stable futures positions although a larger number of speculators are trading or remain below their leverage limit. This time series has significantly less price volatility, and when price flare-ups occur they appear to die down quickly. This may or may not represent greater trading efficiency. The CDA tâtonnement price process still detects the Walrasian price but the mid-point price is not as closely matched as before post τ=1500.

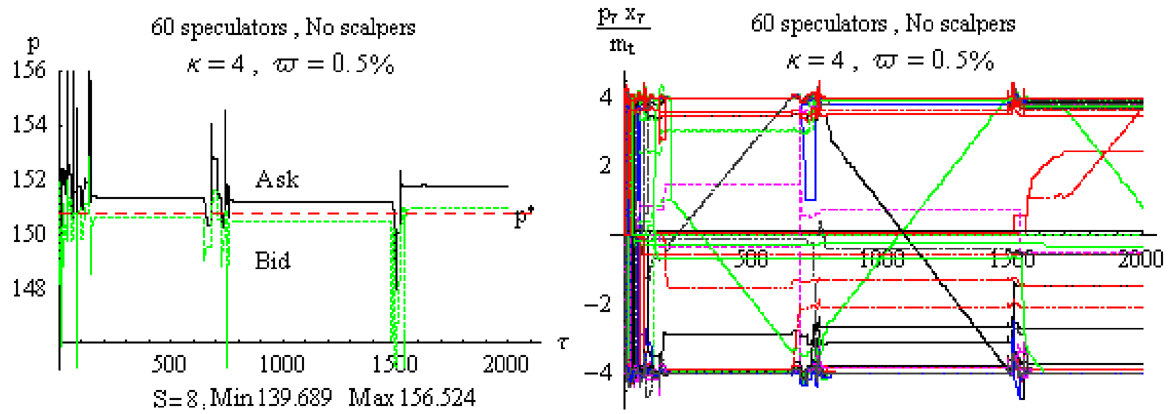


FIGURE 7 Prices and leverage positions for speculators. Margin requirements κ = 4 and tax ϖ = 0.5%.

We also compared two simulations, both with 25% margin requirement but 0.1% versus 0.5% transaction taxes, the regime with the lower cost of trading had greater trading volatility and activity. But despite lower trading volumes for ϖ= 0.5%, there was more competition to move prices back to some middle range reducing the bid-ask spread price volatility. This was

[6] Under a κ=4: ϖ =0.1% regime the average trade was for 8 contracts, whereas for κ=4: ϖ =0.5% it was 3.6 contracts

because of more agents had expectations within the bid ask price spread, even though each regime had the same dispersion of price expectations.

This model suggests that transaction taxes may be a possible method to stabilize highly leveraged markets. There will be more *limit orders* for a given absolute dispersion of expectations and for the same absolute price movements, which in this case is a function of S=8. Since the availability of limit orders adds liquidity and stabilizes markets, then the wider band increases the number of potential limit orders versus *market orders*. This can also be seen at τ =750 in Figure 8 where a very large price drop, does not destabilize the market. Because of the tax threshold, less agents are residing on their leverage limit, see Figure 7, and hence when there is a significant price movement the market as a whole is not placed under a credit crunch and competition brings the prices back to their normal price range quickly.

We shall consider in detail the increase of price volatility from τ =640 to τ =780 in Figure 8. The size of the black and red dots are representative of a log transformation of the trade size. A black dot is a market order by a speculator to either buy at the ask because he expects prices to rise, or sell at the bid because he expects prices to fall. A red dot represents a liquidation of a position in order to meet margin requirements and paying for losses following an adverse price change. A liquidation trade is usually on the backward bending part of the demand function. Since most traders have already taken up their position based on expectations, a lot of the trades that take place are red dots. Prior to τ =650 transactions were randomly distributed between the bid and ask, and trade size averaged around 1.2 contracts with the spread equivalent to the cost of transacting, 0.5 % of the price.

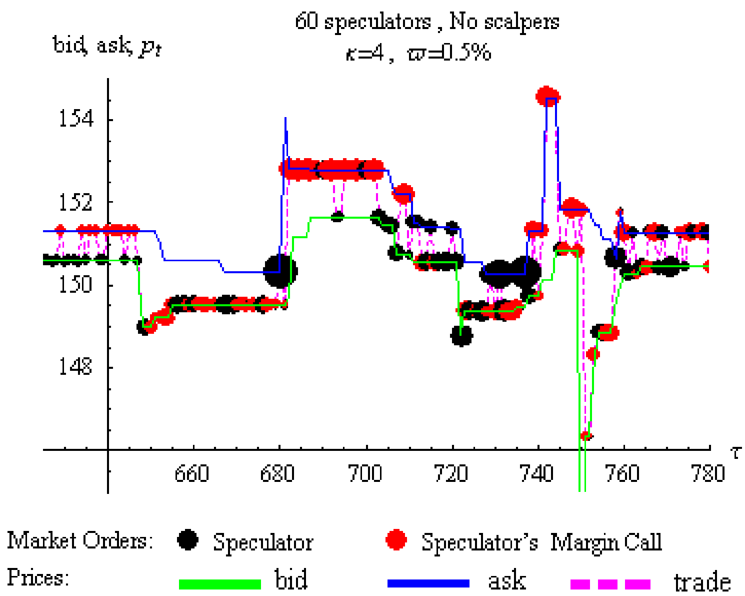


FIGURE 8 Prices and trade size by speculators and hedgers. Trades are market orders only.

In studying the above price destabilizations we have found that buys usually follow buys and sells follow sells. Following what Hasbrouck (2003, p13) noted in stock data - "trades at the bid tend to cause a downward revision in the bid, and trades at the ask cause an upward revision in the ask." In our model this has nothing to do with expectations formation or trend following behavior, rather it is due to collateral constraints causing credit crunches and the forced search for immediacy through market orders due to margin calls. A sudden downward bid is not brought back up but rather stays for a time at that low level. The trades at the low bid are followed by more price transactions at that low bid despite expectations having not changed.

4.3 Simulation for 60 Speculators and 10 Scalpers.

We now turn to a market with 10 additional scalpers along with speculators that have 25 percent margin requirements. All scalpers have the same inventory limit of K=10 each. Scalpers are excluded from holding margin or paying transaction costs, as they are presumed to be local exchange members and do not go through brokers.

Figure 9 is a section of time series for two simulations with low versus high tax regimes, 0.1% versus 0.5% on a one-way trade. The grey trades are market orders done by scalpers. Scalpers will place a market order only when their inventory has reached its limit of K=10, at all other times scalpers provide limit orders at the bid and ask (all limit orders are the counter trade to market orders). There is still a persistence for bids to follow bids (and vice versa for asks). Despite the existence of scalpers there is still such a correlation between prices due to margin or inventory constraints.

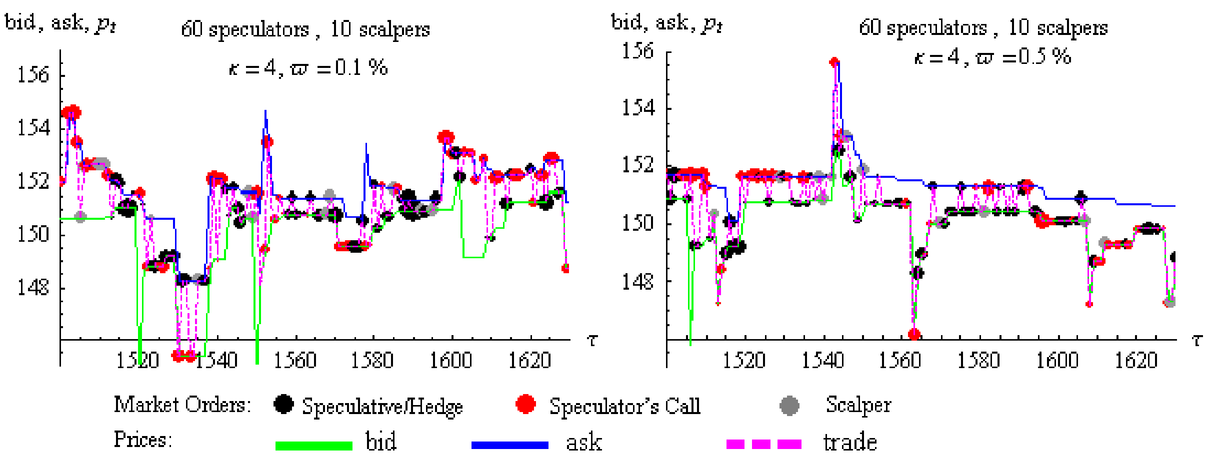


FIGURE 9 Prices and trade size by speculators, hedgers and scalpers. Trades are market orders only.

In almost all cases, adding scalpers raises the standard deviation of the mid-price level, and lowers the degree of kurtosis in the price series. For example for κ =4 and ϖ =0.1%, and no scalpers, the kurtosis of the mid-point price was 20. For the same margin and tax parameters with 10 scalpers the kurtosis was 6. In terms of characterizing price volatility, a slight rise in the standard deviation (from 0.67 to 1.19) was coupled with an overall reduction in extreme price movements. The same result occurred in the higher tax regime: κ =4 and ϖ=0.5%. The simulation with no scalpers had a mid-price kurtosis of 35. When 10 scalpers were introduced, kurtosis was reduced to 5.

An interesting result from introducing scalpers is that both market prices and activity are less sensitive to changes in the tax rate. Unlike the case with no scalpers, an increase in transaction taxes from 0.1% to 0.5% did not reduce trade activity and trade size in our market with scalpers. It also did not increase the average bid ask spread. While the minimum spread in each simulation with scalpers reflects the low or high tax rate ϖp, the average and median spread between the two simulations is very similar.[7] In the scalper markets the bid ask spread was larger on average than in the non-scalper markets, for κ greater than 1, but less sensitive to the tax hike.

As specified by the model, scalpers do not narrow or determine the size of the spread given their overly simplistic trading rules. Myopic speculators determine how wide the bid-ask spread converges to based on their one-way cost of trading. In leveraged markets, scalpers actually increase this bid ask spread, even while reducing extreme mid-price movements.

Scalpers, who have no opinion about fundamental prices, will provide liquidity not only to those traders that stabilize markets, but also to those traders that destabilize markets. Scalpers appear to not only maintain the bid-ask spread but they can also indirectly widen it. When a *noise* or uninformed trader, in our case a speculator with price expectations that are outside of the bid ask spread, wants to trade but finds that liquidity has dried up (faces a zero limit order) then they can quickly raise ask prices if they had originally wanted to buy, or lower bid prices if they had originally wanted to sell. Scalpers are ready to accommodate such prices. By accommodating such a price which is wide of the previous price structure, competition among speculators is forfeited. After a short time span scalpers may widen the spread even more by reversing their own excessive inventory position from accommodating the 'uninformed trader', lifting or hitting the opposite side of the market, creating a zero limit order and leading to a widening of the spread again. This will mean that the mid-price may be mean reverting, but the spread initially widens on both sides before narrowing.

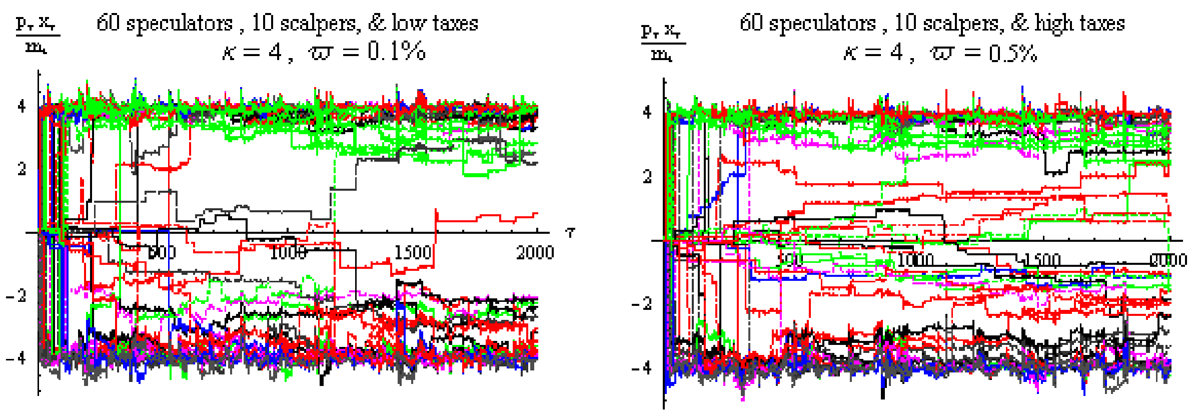


FIGURE 10 Leverage positions for speculators in a market with margin requirements κ = 4 and scalpers. Comparison of 0.1% vs 0.5% transaction tax.

[7] For the simulation with 10 scalpers and κ=4: ϖ=0.1%, the mean and median bid-ask spread, as a percentage of the price, was 0.92 and 1.3, with a minimum of 0.11. For the simulation with 10 scalpers and κ=4: ϖ=0.5%, the mean and median bid-ask spread, as a percentage of the price was 0.8 and 1.2, with a minimum of 0.5.

Scalper markets might also be considered to be more liquid if one were to consider volume as an indicator of market liquidity or the proportion of traders below their leverage limit as in Figure 10. Alternatively, they are less liquid if the measure is the average bid-ask spread. The market with scalpers appears to make mid-prices more resilient from an imposition of a higher transaction costs, as long as these costs are imposed on the speculators and not the scalpers. Exempting market makers from a Tobin Tax might be a suggestion for such a policy to be successfully implemented: remove noise traders but not at the cost of liquidity and less price resiliency.

Speculator wealth is much more erratic, and in our zero sum market minus the cost of taxes which goes as exchange revenue[8], there is a transfer of wealth from speculators to scalpers. Scalpers are not charged a transaction tax, but as the transaction tax rises speculators reduce their trading volume and income earned on intermediation by the scalper is reduced. We can see this in Figure 11 where scalper wealth is higher for the lower tax regime.

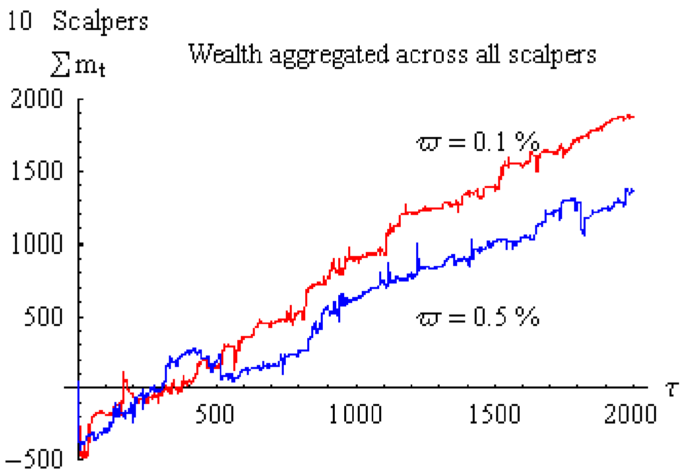


FIGURE 11 Comparison of scalper wealth in a low tax versus high tax market where κ=4.

5 CONCLUSION

This preliminary unpacking of the Walrasian black box of exchange has shown that even with the inclusion of leveraged trading, short selling, RTGS and transaction costs, our market is relatively stable and reverts to the Walrasian equilibrium price in the long run. A market of speculators, with diverse expectations and no scalpers, will produce a competitive bid-ask spread that fluctuates and often narrows to the cost of transacting ϖp.

Margins and transaction taxes directly effect the distribution of market orders to limit orders for a fixed distribution of expectations. Without scalpers, lowering the margin requirement increases the sensitivity of demand to price changes and increases the degree of trading activity in the market. The bid-ask spread is wider but mid-prices are more resilient, that is the kurtosis level of the price distribution is lower. Speculators with expectations that are closer to the long run price p^*, and especially those within the tax threshold, gain from trading in

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[8] In the inter-day trading model, we have proposed that interest is paid on margin accounts which keeps aggregate wealth stationary (Ussher 2005).

a low margin low tax environment due to their ability to play the role of market maker and earn a spread from the noise traders. The greater leverage allowed in the market, the more impoverished the noise traders become. This follows Friedman's (1953) Darwinian process that low margins quickly sort out the "smart" traders from the "noisy" ones. A larger transaction tax can stabilize prices. An increase in the tax threshold increases the number of speculators who compete to offer limit orders when prices become unstable. This stabilizes the price process and equates order flow. However, while prices are stable in this market, they are less resilient (higher kurtosis).

When scalpers are included into the trading mix the bid-ask spread is wider, order flow is turbulent, and trading volume is much greater. Despite the larger spread, this may be characterized as a more liquid market and mid-prices are dramatically more resilient. Changing transaction taxes has less impact on both trade activity and price volatility. However, raising taxes still accomplishes its goal of impoverishing traders with expectations far away from p*.

This simulation, as yet has only anecdotal results, but it suggests ways forward to give structure to the bidding and price process of a futures markets, while at the same time contribute to a discussion aggregation, market institutions and optimal market design.

APPENDIX

The risk-neutral speculator maximizes next periods expected wealth (1). The first four of our boundary constraints represents the limit on a speculator's investment by the margin requirement when one is short in futures, (2) and (3), versus the extent to which futures can be bought long, (4) and (5). We have two each of these restrictions to take into account the one-way tax on both buys and sells $\varpi\ p_\tau\,|\,(x_\tau - x_{\tau\text{-}1})\,|$ for speculator *i*. If the transaction tax is positive then this boundary constraint will be slack. This dual tax restriction also impacts the budget constraint, (6) and (7). The bankruptcy conditions (8) through (12) stop money wealth from going below zero.

For speculator *i*:

Maximize:

$$\pi^e_{t+1} = \left(p^\theta - p_t\right)x_t + m_t \tag{1}$$

Subject to:

$$p_t x_t \geq -\kappa\left(\left(p_t - p^m_t\right)x_{t-1} + \left(p^m_t - p_t\right)\left(x_t - x_{t-1}\right)m_{t-1} - \varpi\ p_t\left(x_t - x_{t-1}\right)\right) \tag{2}$$

$$p_t x_t \geq -\kappa\left(\left(p_t - p^m_t\right)x_{t-1} + \left(p^m_t - p_t\right)\left(x_t - x_{t-1}\right)m_{t-1} + \varpi\ p_t\left(x_t - x_{t-1}\right)\right) \tag{3}$$

$$p_t x_t \geq \kappa\left(\left(p_t - p^m_t\right)x_{t-1} + \left(p^m_t - p_t\right)\left(x_t - x_{t-1}\right)m_{t-1} - \varpi\ p_t\left(x_t - x_{t-1}\right)\right) \tag{4}$$

$$p_t x_t \geq \kappa\left(\left(p_t - p^m_t\right)x_{t-1} + \left(p^m_t - p_t\right)\left(x_t - x_{t-1}\right)m_{t-1} + \varpi\ p_t\left(x_t - x_{t-1}\right)\right) \tag{5}$$

$$m_t \leq \left(p^m_t - p^m_{t-1}\right)x_{t-1} + \left(p^m_t - p_t\right)\left(x_t - x_{t-1}\right) + m_{t-1} - \varpi\ p_t\left(x_t - x_{t-1}\right) \tag{6}$$

$$m_t \leq \left(p^m_t - p^m_{t-1}\right)x_{t-1} + \left(p^m_t - p_t\right)\left(x_t - x_{t-1}\right) + m_{t-1} + \varpi\ p_t\left(x_t - x_{t-1}\right) \tag{7}$$

$$0 \leq \left(p^m_t - p^m_{t-1}\right)x_{t-1} + \left(p^m_t - p_t\right)\left(x_t - x_{t-1}\right) + m_{t-1} - \varpi\ p_t\left(x_t - x_{t-1}\right) \tag{8}$$

$$0 \leq \left(p^m_t - p^m_{t-1}\right)x_{t-1} - \left(p^m_t - p_t\right)\left(x_t - x_{t-1}\right) + m_{t-1} - \varpi\ p_t\left(x_t - x_{t-1}\right) \tag{9}$$

$$0 \leq \left(p^m_t - p^m_{t-1}\right)x_{t-1} + \left(p^m_t - p_t\right)\left(x_t - x_{t-1}\right) + m_{t-1} + \varpi\ p_t\left(x_t - x_{t-1}\right) \tag{10}$$

$$0 \leq \left(p^m_t - p^m_{t-1}\right)x_{t-1} - \left(p^m_t - p_t\right)\left(x_t - x_{t-1}\right) + m_{t-1} + \varpi\ p_t\left(x_t - x_{t-1}\right) \tag{11}$$

$$m_t \geq 0 \tag{12}$$

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