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Adam Smith's Invisible Hand Revisited. An Agent-Based simulation of the New York Stock Exchange

Agent-Based Simulations are often highly stylized representations of the circumstances they aim at emulating. We've tried instead to replicate to a high degree of complexity, the operation of the New York Stock Exchange, being fully aware that some of the detail in verisimilitude has no impact on price formation and trading volumes involved.

The trading modeled is that of a single Stock. A Stock Exchange sees of course the trading of a multitude of stocks. The price of each of those evolves however largely independently, making a Stock Exchange essentially a juxtaposition of stocks rather than an integrated whole.

Three types of agents are made to interact on the New York Stock Exchange, the only remaining Exchange with an "open outcry" where human agents directly interact: Clients passing orders, Traders executing them with the help of Market Makers acting as catalysts.

Clients (Institutional and individual) pass Limit Orders to Traders. An order is an injunction to Buy or to Sell, a certain number (volume) of shares in the Stock at a particular price, called a Bid for a Buyer and an Ask for a Seller. The book of its Limit Orders is a Trader's Deck.

Traders attempt to match between them the Limit Orders in their Deck. Market Makers are appointed by the Exchanges to offer a last recourse to Traders who fail to match the Limit Orders in their Deck, by being at all times prepared to both Buy and to Sell – that is, at the Bid and the Ask levels they themselves determine.

A transaction takes place when an order to Buy meets an order to Sell at the same price, i.e. when the Bid is equal to the Ask; this price is then called a Settlement Price or “Settle”. The lower of the two volumes of the Sell and the Buy Limit Orders determines the volume of the transaction. The order which had the higher of the two volumes is then left with a remainder of shares to buy or to sell, which may or not consolidate with an existing one.

A surviving order, when all others have found a match at a particular Settle, will induce a Trader to lower an Ask or raise a Bid. It is therefore the Limit Orders that fail to be fulfilled that drive the Market to new Settles. A session is composed of a number of such efforts to match Buy orders with Sell orders.

A Buy followed by a Sell materializes into either a Profit or into a Loss for the Client who gave these two sequential Limit Orders.

When issuing new orders, Clients follow strategies of two types:

1. Following the trend: Buying when price goes up and Selling when price goes down.
2. Taking their profit (“contrarian” strategy): Selling when price has climbed by a determined amount, Buying when prices have come down by a determined amount.

It is the set of these assumptions described above that have been implemented in my Agent-Based simulation of the New York Stock Exchange.

Program

The simulation program is written in C# 2.0 (Visual Studio 2005). The program is Object-Oriented. The classes are the following:

Class Market

A Market has a Name

and a tick, the smaller increment or decrement in Price,

a List of Traders: Markets' Traders,

a List of MarketMakers: Market Makers,

a List of Transactions: Market's Activity.

Class Trader

A Trader has a Name and

a List of Limit Orders: myDeck

Class LimitOrder

A LimitOrder has a Client: Source,

a BuyOrSell: Direction,

a Target Price and

a Contract Volume

Class Client

A Client has a Name,

a TimeHorizon (to judge if the Price is moving up or down),

a ReverseLevel (at which to reverse from Buyer to Seller or from Seller to Buyer)

and a Profit or Loss

Class MarketMaker

A Market Maker has a Name,

a BidAndAsk: Positions

and a Profit or Loss

Class BidAndAsk

A BidAndAsk has a BidVolume,

an AskVolume,
a Bid (Price) and
an Ask (Price)

Class Transaction

A Transaction has a Settle (Settlement Price),
a Volume,
a Traders' Name (on behalf of the Buyer Client)
a Client's Name (Buyer),
a Traders' Name (on behalf of the Seller Client),
a Client's Name (Seller) and
a Session Number

Results

The simulation reveals the following:

Price:

1. When Clients don't develop strategies, the price of the Stock fluctuates around its initial level with a seemingly tendency to mean-reversion.
2. On the other hand, when Clients develop strategies (whether Trend Following or a combination of Trend Following and Profit Taking) the market ends up crashing. The presence of Market Makers acts as a damper to this tendency.

Profit / Loss:

1. Some Clients accumulate large Profits, some others, large Losses.
2. There is a tendency to concentration, with the number of Clients and Traders executing their orders, diminishing regularly as a session develops.

Conclusion

Clients' strategies breed positive feedback that leads the market to accelerate its movement, soaring or nose-diving, in which case of course it crashes. These features underline that the purposive behavior (developing strategies) of agents does not display the self-regulating effect often talked about, quite the contrary in fact. This observation suggests that there is no "invisible hand" resulting from the interaction of these agents.

Markets like Stock Exchanges have introduced explicit regulations of their own, like "trading halts," market interruptions that aim at preventing crashes when prices start to dive. These rules seem to meet their goal. To that extent, the only "hand" guiding the Stock Market is "visible".

How to explain then the commonly held belief in the "invisible hand"? An element of self-regulation derives no doubt from the players' "fair play", i.e. their conscious or unconscious efforts to maintain the operation of the Market (Aristotle's "philia".) More pervasive however is the fact that the free operation of the Exchanges creates outright winners and losers. It is the vested interest of the winners to claim that Stock Markets are self-regulating. Their financial success provides them with the means to propagate that self-serving view.