MODELLING CHART PATTERNS

with Heterogeneous Agent Model

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Outline

- Introduction
- Model
- Simulation Results
- Conclusions

Introduction

- Motivations:
  - technical analysis, especially **pattern analysis**
  - widely-used by practitioners
    (Taylor and Allen,1992; Cheung and Chinn, 2001)
  - profitable, earning extra profit

(Brock et al., 1992) showed the predictive power of technical trading rules in the U.S. stocks for over 30 years.

(Osler and Chang 1995)proved the profitability of the head-shoulder patterns.

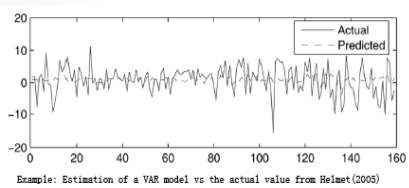
(Neely et al., 1997; Dueker and Neely,2007) noticed the advantages of the technical analysis in the exchange markets.

(Allen 1999) tested the the technical rules actually could help the investors to earn an excess return compared to the random walk model and Garch model.

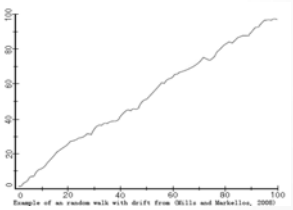
Introduction

❖ Pitfalls about traditional financial models

1. Financial econometrics model: low goodness of fit, spurious effects , (Terence C. Mills and Raphael N. Markellos 2008)
2. Unable to generate a price movement compatible with the real market, not even mention the chart patterns (Helmet, 2005)



Example: Estimation of a VAR model vs the actual value from Helmet(2005)



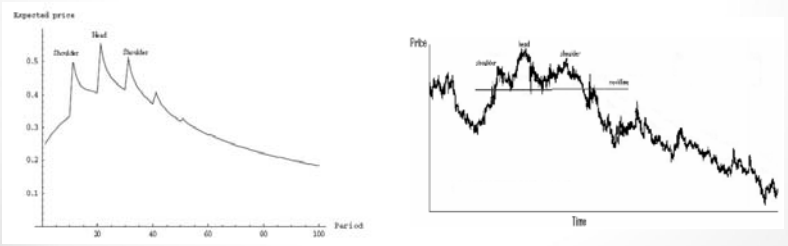
3. involving the stochastic process, making it hard to explain the mechanism to generate those patterns

Introduction

Especially,

(Friesen, Weller, and Dunham 2009) in *Journal of Banking & Finance*

- Only simulated the Head and Shoulder patterns and double tops patterns
- Jump-diffusion process, including three types of signals, L-signals, M-signals and H-signals with different frequencies.
- Below are their simulation results vs. the patterns in the real market.



Introduction

- Two main characteristics of our model based on two premises in technical analysis (Murphy 1999)
  - Premise 1: "price actions indeed reflect shifts in supply and demand between different investors."

    So we apply the HAM to explicitly include the interaction between investors to generate.
  - Premise 2: "history repeats itself. "

    We introduce a purely deterministic price dynamics so that all the parameters in our models are controllable and traceable.

Model

Under the basic frame work of Day and Huang(1990)
Totally three types of participants,

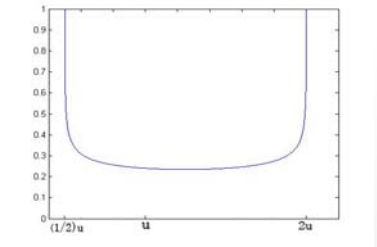
- Fundamentalists
  - Can access to all the internal information
  - Price will fluctuate around the fundamental value of the risky asset and the price will converge to its fundamental value after all.
  - Buy in when the current price p_t< fundamental value u^f
  - Sell out when $p_t > u^f$
  - Therefore , the excess demand $\alpha(p)$ can be expressed as
  - $$\alpha(p) = \begin{cases} (u^f - p_t)\varphi(u^f, p_t) & if\ p \in [m, M] \\ 0 & if\ p < m\ or\ p > M \end{cases}$$

Model

Remark 1 Chance Function

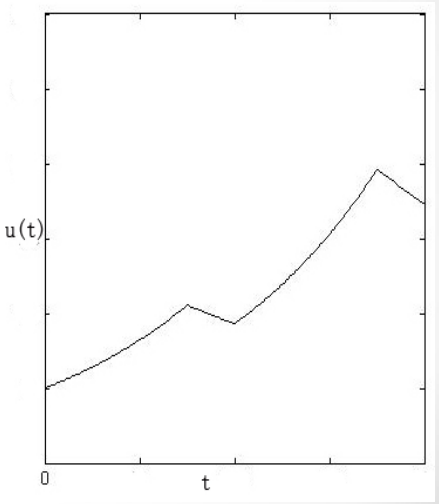
$$\psi(p,u) = a\left(p_t - \frac{1}{k}u\right)^d (ku - p_t)^d$$

In the expression of $\alpha(p)$, the $\varphi(u^f, p_t)$ is the **chance function** of fundamentalists, which depicts the the lost opportunity of investors. For example, when the price get closer to the topping price M, the probability to lose the gain is getting higher. Visa Versa.



Model

- Remark 2: In order to be more compatible with the real market, The fundamental value *u(t)* in our paper is no longer like a constant. It will fluctuate following a simple **business cycle**, with *3s* period of expansion and *s* period of recession.



Model

The economic growth function g(t)

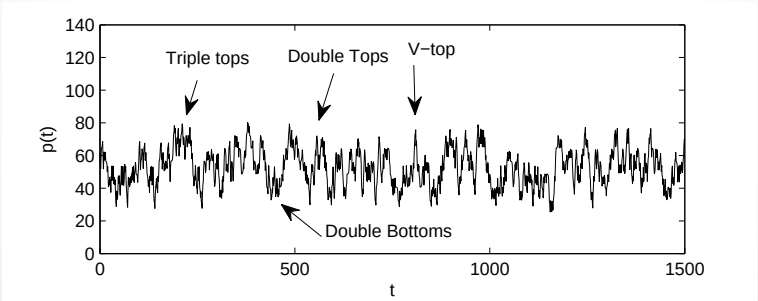
$$u_{t+1} = g(t) \cdot u_t$$

and

$$g(t) = \begin{cases} g & t \in [4(i-1)*s, (4i-1)s) \\ \frac{-g}{2} & t \in [(4i-1)s, 4i \cdot s) \end{cases} \qquad i=1,2,3,\ldots n$$

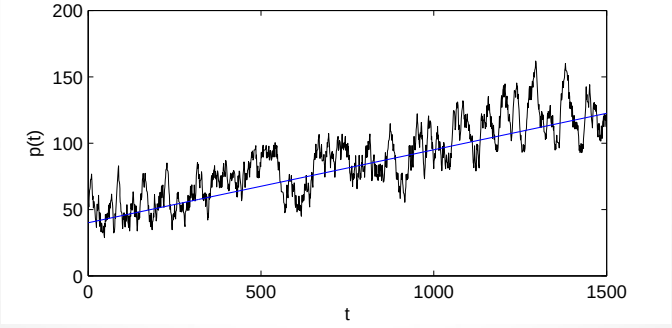
Model

- Here, it is noticeable that even without the introduction of business cycle, the chart patterns can still be found in our simulations. So the existence of the chart patterns should still attributes to the market maker framework.



Model

And keep all the parameters the same, just add the new parameter of economic growth, the new simulated series we generated is as below. We could see a clear upward trend in the series, which is more compatible with reality.



Model

- Chartist
- Trend-chaser: when p_t > the short run fundamental value u^c there will be positive excess demand . Vice versa.
- The **opposite Strategy** with Fundamentalists
- Therefore,
  the excess demand for chartists

$$\beta(p) = b(p_t - v_t) \qquad b>0 \qquad (2)$$

Model

- In equation above, Short-run fundamental value u^c follows a **regime-dependent process** (Huang, Zheng, and Chia 2010))
- Firstly, the chartist will divided the whole trading regime into n mutually exclusive regime with the same length,

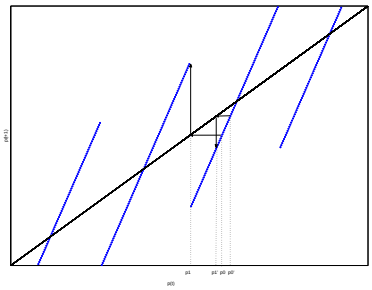
$$\cup_p = \cup_{i=1}^{n} P_i = [P_0, P_1) \cup [P_1, P_2) \cup \cdots \cup [P_{n-1}, P_n]$$

$$P_k - P_{k-1} = \lambda \quad , \qquad \lambda \text{ is a constant}$$

- Each boundary is a psychological threshold for the investors. Therefore, when current price p_t falls into a specific regime $[P_{k-1}, P_k)$ the expectation for the u^c is equal to the average of the topping and the bottom price for that regime.
- $$u^{ce} = \frac{P_{k-1}+P_k}{2} \quad \text{if } p_t \in [P_{k-1}, P_k), k = 1,2,\dots,n$$
- Furthermore, the short run fundamental value can be simplified as
- $$u^{ce} = \lfloor p_t/\lambda \rfloor + \lceil p_t/\lambda \rceil \cdot \lambda \quad \text{if } p_t \in [P_{k-1}, P_k), k = 1,2,\dots,n$$

Model

- Therefore, a regime dependent process would like as below
- u^c unchanged: when the price moves within the same regime bounded by the support and resistance price level
- u^c changed: when the price break the psychological threshold for the price



Model

- Third participant: Market Maker
- (Day and Huang1990; Farmer and Joshi 2002; CHIARELLA and HE 2003, He and Li 2007)
- Taking up the excess demand or supply from the other two investors by using his inventories.

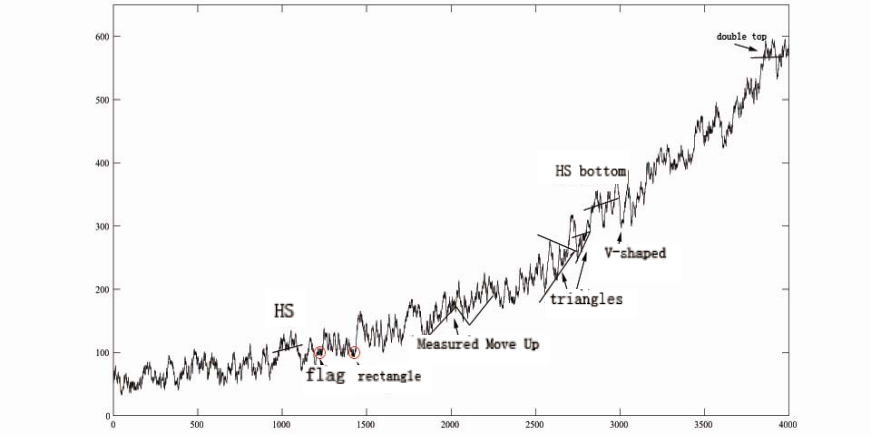
$$V_{t+1} - V_t = \alpha(p) + \beta(p) \quad (5)$$

Here, V is the inventory of the market maker
So the adaptive price setting process is

$$p_{t+1} = p_t + c\,(V_{t+1} - V_t) = p_t + c(\alpha(p) + \beta(p)) = f(p_t) \quad (6)$$

Concludedly, the price is following an one-dimensional deterministic nonlinear dynamics.

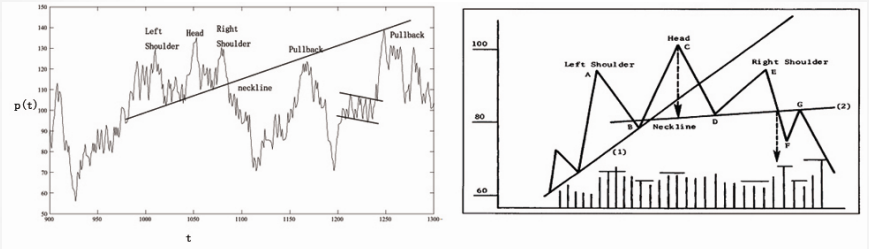
Simulation Results



$u_1 = 50, d_1 = d_2 = -0.3, k = 2, \lambda = 7.5, s = 25, a = 1, b = 2.25, c = 1.2$

Simulation Results----HS top

Head and Shoulder pattern(HS) at t=900-1300



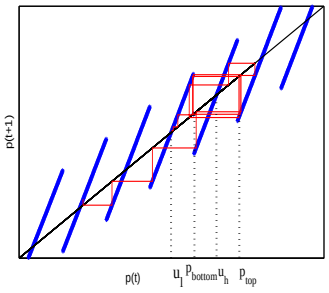
- A prior uptrend
- three peaks which called left shoulder, head and right shoulder.
  the "head" is the highest and the left and right shoulders are at about the same height.
- "neckline", which connect the two bottoms.
  Once the price break the neckline, the return move after the pattern will not recross this line normally.

Simulation Results----HS top

Phase diagram for a simple head and shoulder pattern

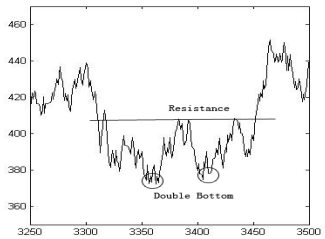
Almost every HS pattern has two highly identical lower loops, which indeed consist of the right shoulder and left shoulder. Meanwhile, there's a comparatively small loop at the very top of the phase diagram which becomes the watershed of the rise and the decline.

The possible explanation for the predictive power shown in our results lies in the introduction of multi-regime dependent beliefs of the chartist. The thresholds(like p_{bottom}, p_{top}) set up by the chartist actually represents the support lines and resistance lines.



Simulation Results----Double Bottom(W-shaped)

- Similarly, we could retrieve the inverse pattern of double top, double bottom, or as we called "W-shaped".
- The phase diagram for the W-shaped is also similar to the M-shaped.

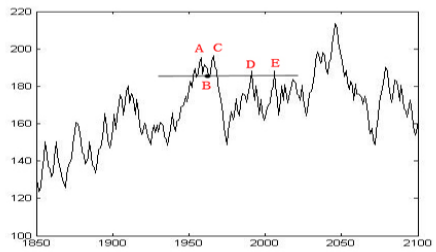


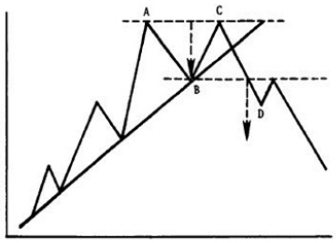
Our simulation results

an example of UTX during the time from Aug. 1997 to Feb. 1998

Simulation Results----Double Top(M-shaped)

The last pattern we seen in our diagram is the double top.
Actually, there's two Double Tops in the time series from 0 to 4000.
We take the one from 1850 to 2100 as for example.

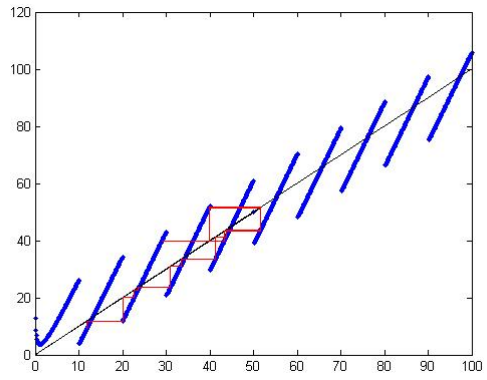




- There are two tops at about the same height A and C.
- The horizontal line of the trough B is the confirmation level.
- Once there's a breakout, the Pullback D and E in short time is hard to recross the confirmation level.

Simulation Results----Double Top(M-shaped)

- Phase diagram for the double top

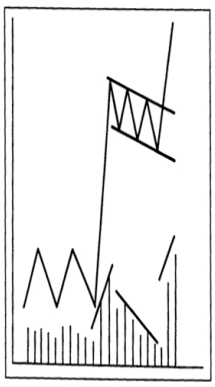


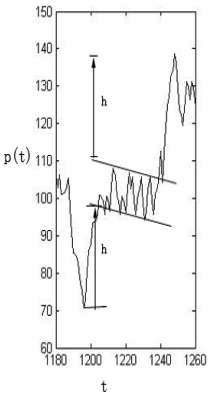
The characteristics for the phase diagram for DT:

Two highly resemble loops at the top, which actually explicitly can be seen as the double tops, and after the second loop, the price will fall into the "decline zone" and go through a continuous fall down.

Simulation Results----Flags

- Flags(and Pennants)when t=1180-1260

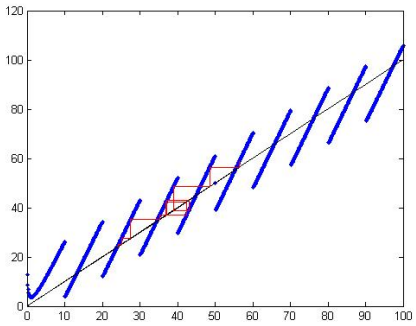




•After a sharp move
•The flag should slope against the trend
•The flag normally occurs at the midpoint of the whole move

Simulation Results----Flags

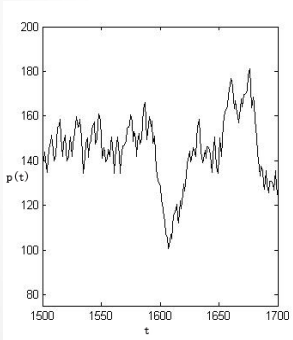
- Phase diagram for a simplified flag



The typical phase diagram of flags is quite clear that after a continuous climbing, the price fall into a “loop” zone that normally the price will be trapped into this zone for a while and there would be several highly identical loops repeated. However, once there’s a breakout, the price will arise with great impetus.

Simulation Results----V-shaped

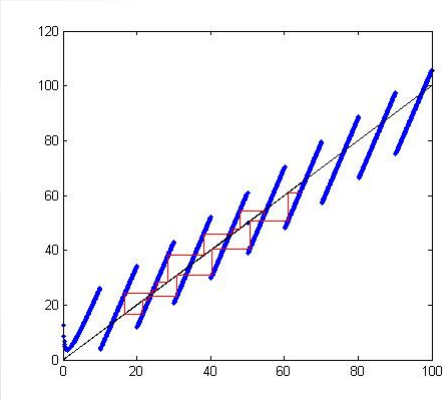
- To achieve better results, we take the V-shaped when p(1)= 61.13 as example.



V shaped is rarely seen, however, most of cases the magnitude of V-shaped is really huge and normally assumed as due to some unpredictable external disturbances. We are also able to demonstrate that a purly deterministic nonlinear price dynamic can also be the factor underneath determining the sudden drop and sudden rise which could cause huge loss and gains for almost half of the stock value during a very short period.

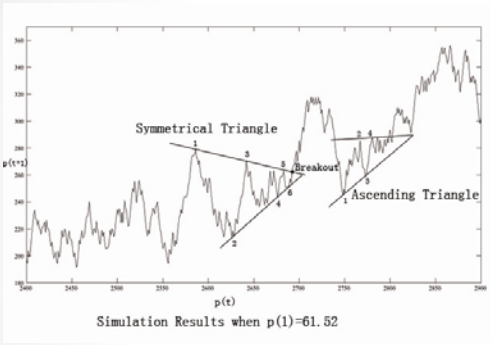
Simulation Results----V-shaped

Phase diagram for the V-shaped

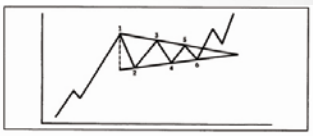


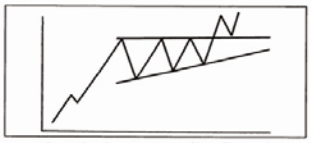
The phase diagram for the V-shaped is also very attractive and astonishing.
All the points are divided into two groups by the 45° line, at the first part, all the prices are falling into the "declining zone" which results in a continuous dropping. Then after a turnover, all the points jump above the 45° line

Simulation Results----Triangles



Simulation Results when p(1)=61.52

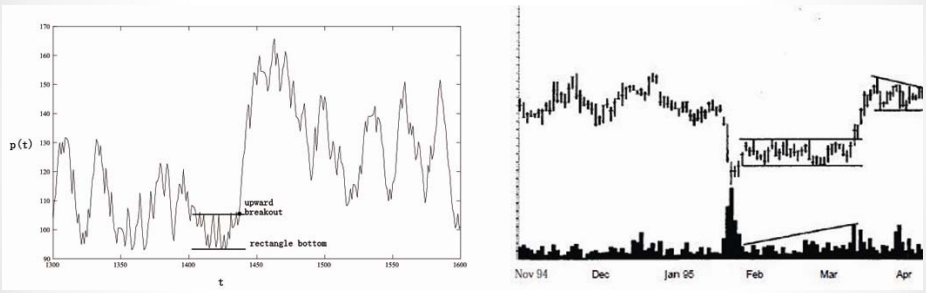

Example for a Symmetrical Triangle


Example for an Ascending Triangle

•Symmetrical Triangle is a continuation pattern, previous trend will resume after the pattern
• Ascending Triangle is an absolute bullish pattern

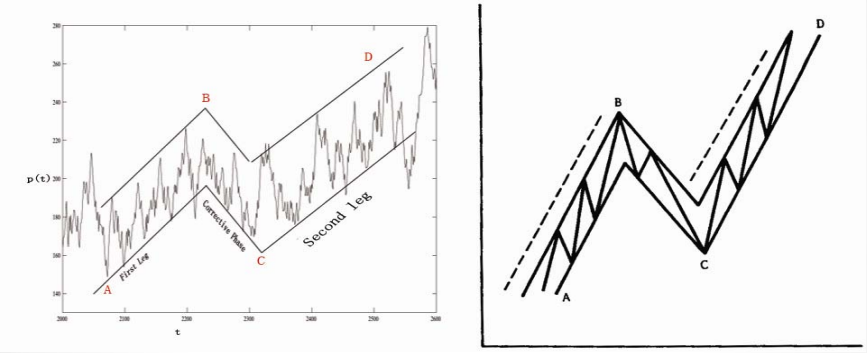
Simulation Results----Rectangles

- Rectangles when t=1400-1500



• Can be either a reverse or a continuation pattern
•The power between the demand and the supply is oscillated until there is a penetration

Simulation Results----Measured Move Up



- "CD" duplicates both the size and the slope of "AB"
- "BC" often retrace 1/3 to ½ of "AB" before the trend is resumed

Test of Stylized Facts

- Fat tails

Statistics	Skewness	Kurtosis	Maximum	Minimum	SD
lr_result	-0.173	**13.4**	0.466	0.064	-0.077
lr_djia	0.274	**14.9**	0.094	0.014	-0.110
Lr_sp500	0.025	**14.8**	0.105	0.013	-0.082

Note: The lr_result represents the log return series of our simlation results. The lr_djia and lr_sp500 represents the log return series of the daily data of DJIA and SP500 from 03/07/2003-03/07/2010

Test of Stylized Facts

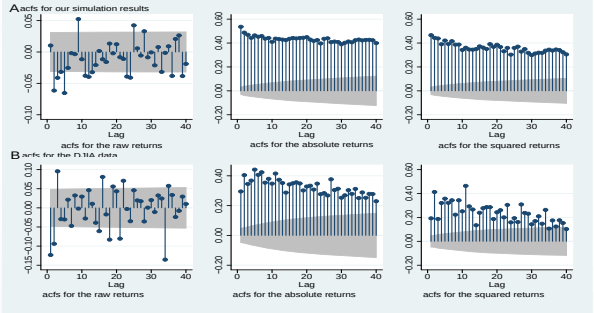
- Unit Root

Dickey-Fuller test for unit root (No. of obs: 4000)	Price p_t	Return r_t
Test statistics	0.024	**-62.5**
P-value	0.961	**0.000**

Note: We test the unit root process for both the original price series and the Return series, the first difference of the price series by Augment Dickey Fuller test. The results strongly show that the price series has the unit root process but the return series don't.

Test of Stylized Facts

Volatility Clustering



Note: The group A are the acfs for the raw returns, the absolute returns and the squared returns for our simulated results, and the group B are the same results for the DJIA.

Conclusion

- Successfully generating price trends which are highly compatible with the real markets with a simply deterministic HAM.
- Capable of replicating all familiar patterns, including reverse and continuation patterns in technical analysis.
- Providing supports for the predictive power of the chart patterns
- Exploring the internal mechanisms by deriving the phase diagrams of each pattern
- Test the fitness of our models with the financial stylized facts

Thank you for your time!

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