Animal Spirits in the Foreign Exchange Market

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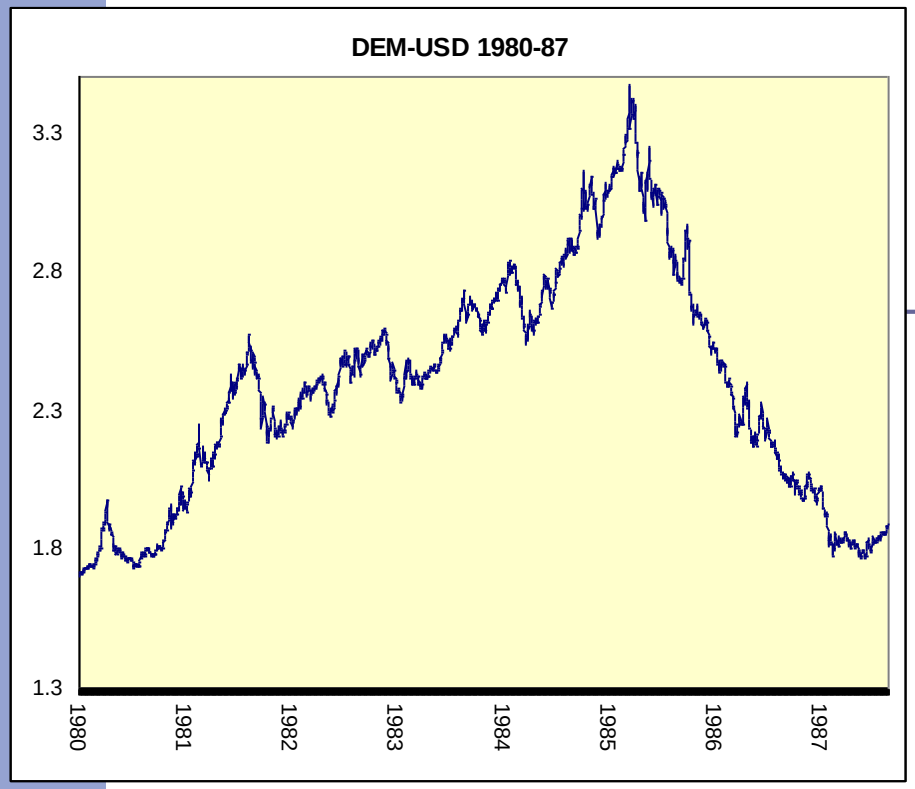
Standard exchange rate theory

- Rational-expectations-efficient-market (REEM) paradigm:
  - Agents continuously maximize utility in intertemporal framework
  - Forecasts are rational, i.e. take all available information into account, including the one embedded in the model
  - Markets are efficient: prices reflect all relevant information

Cracks in the REEM Construction

- One of the predictions is that exchange rates can only change because of news in the fundamentals.
- This prediction must surely be rejected

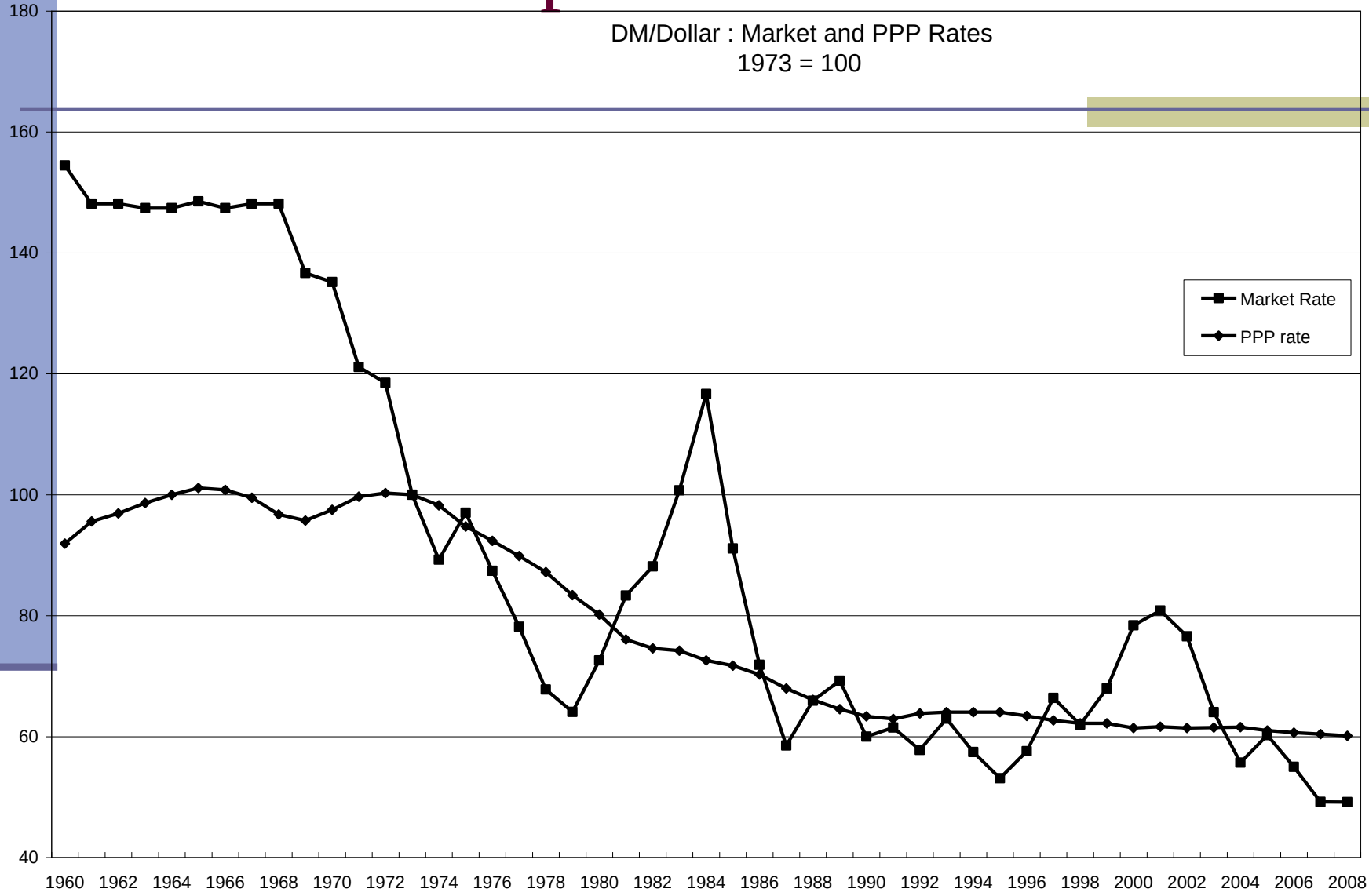


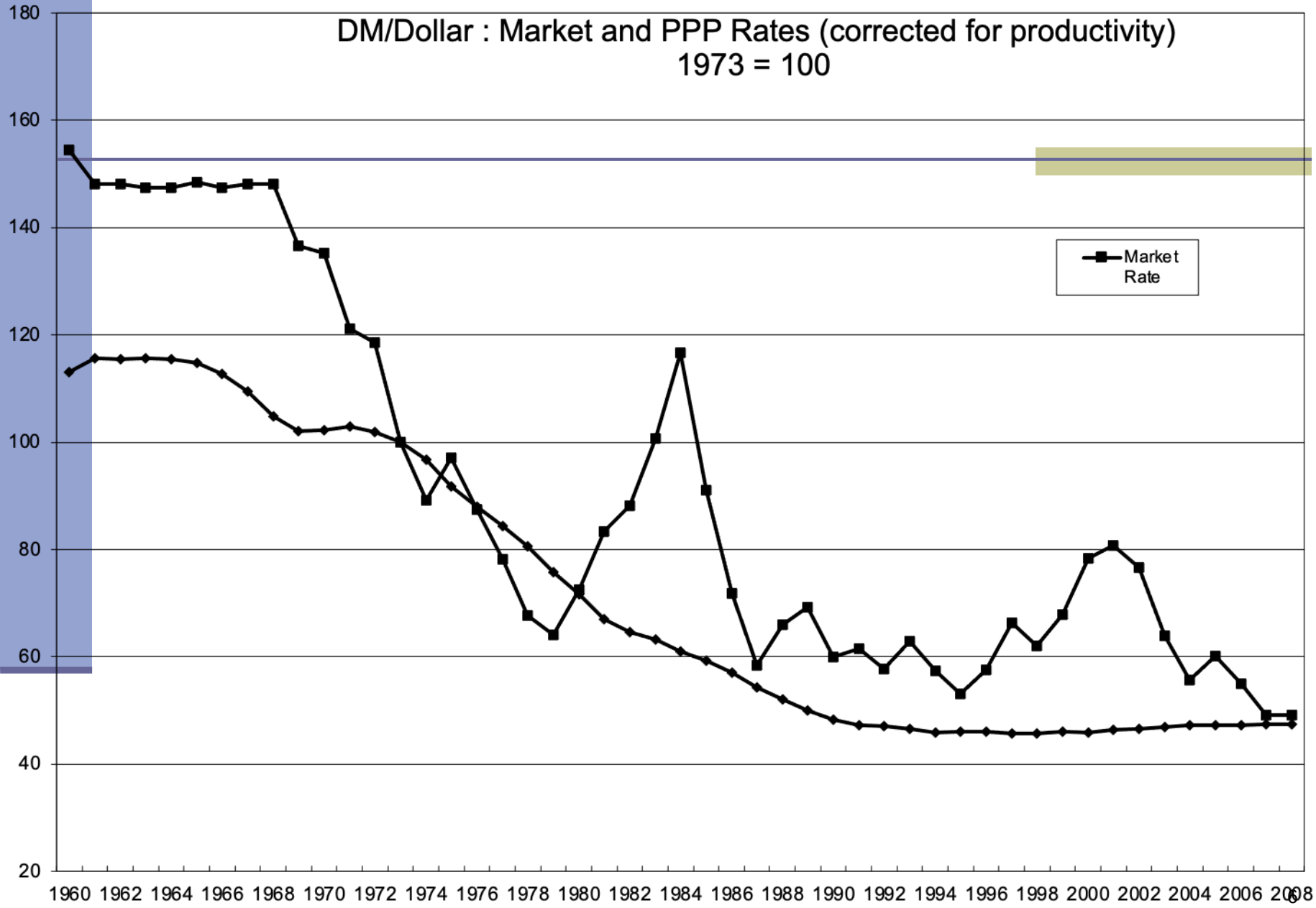
Two bubbles and crashes

News model can only explain this by first a very long series of positive news followed by long series of negative news

There is just not enough news to do the trick

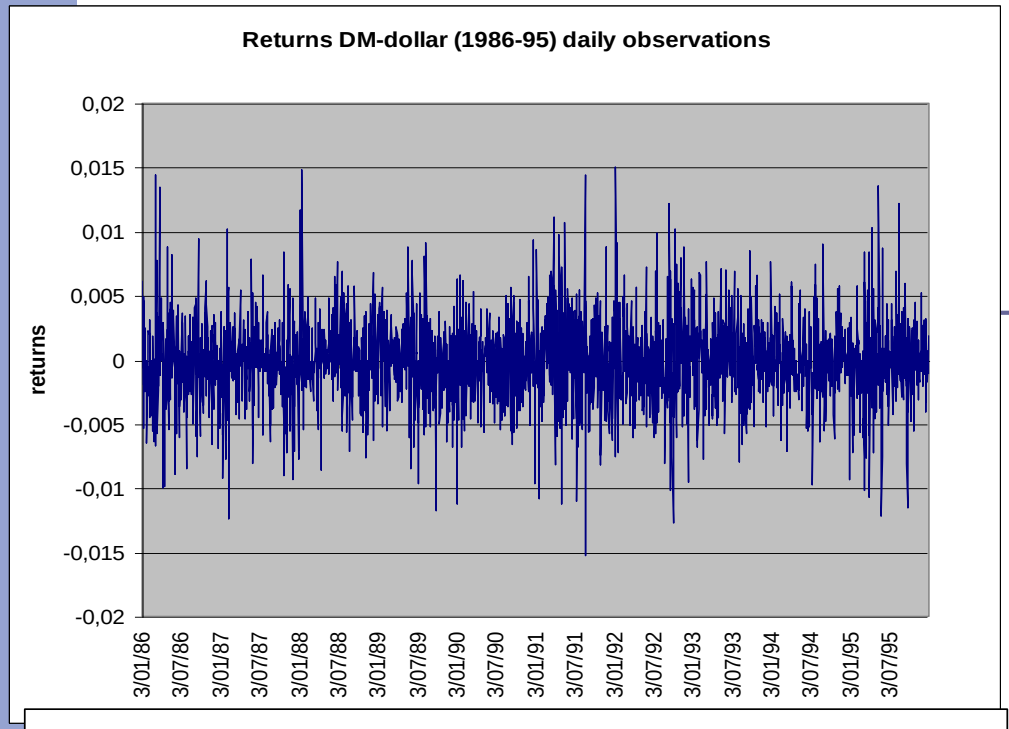
Disconnect puzzle

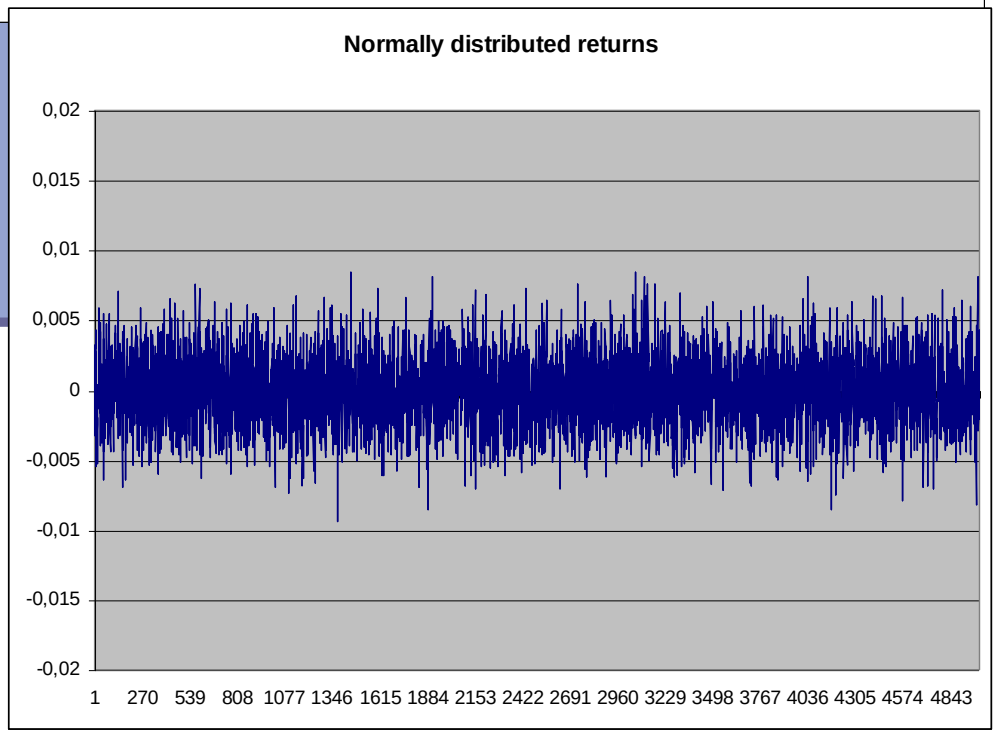



DM/Dollar : Market and PPP Rates (corrected for productivity)
1973 = 100
Market Rate
180
160
140
120
100
80
60
40
20
1960 1962 1964 1966 1968 1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008

- Previous graph also shows another empirical anomaly:
- Exchange rate is disconnected from underlying fundamentals most of the time
- This is the disconnect puzzle
- Spectacular example: failure of PPP

- There are other anomalies that cannot be explained by the REEM-model
  - Fat tails and excess kurtosis
  - Volatility clustering





Sharp spikes and

Clustering of volatility

There are five spikes that exceed 5 standard deviation

One such spike should be observed only once in 7000 years if exchange rate changes are normally distributed.

Mainstream theory explains this by assuming these features are present in the stochastic shocks

We have to do better than "shockology"

- Implicit in the REEM model is the view that agents (at least some of them) understand the structure of the underlying model and that they use this information to make predictions
- This means that some agents can store and process in their individual brains the full complexity of the information lying out there in the world.
- An extraordinary assumption
- Such an extraordinary assumption should only be used if it leads to powerful empirical predictions
- The fact is that it does not.

Alternative APPROACH: behavioural finance tradition

- Agents have a limited capacity for understanding and processing the complex available information (bounded rationality).
  - In order to cope with the uncertainty they use relatively simple behavioral rules (heuristics).
  - This does not mean they are irrational.
  - Because the world is so complex it is pointless to try to understand its full complexity
- Rationality in the model is introduced by assuming that agents are willing to learn. They follow a procedure that allows them to evaluate the simple rules
- And to switch to the more profitable one

- Agents compare the rule they currently use to alternative rules
- They decide to switch to the alternative if it turns out that this is more profitable (fitness criterion; evolutionary dynamics).
- This procedure is also a disciplining device: we have to avoid that all simple rules are possible; there must be a selection mechanism that only keeps the best rules

A behavioural model

- Consists of three blocks
  - Optimal portfolio based on mean variance utility maximisation
  - Expectations formation of heterogenous agents : simple behavioural rules
  - Deciding about the forecasting rules: fitness criterion

1st block: derivation of demand for foreign exchange

- Demand for foreign exchange determined by
  - interest differential (r – r*)
  - Expected future exchange rate
  - Degree of risk aversion

2nd block: expectations formation

- There are two types of forecasters

1. Fundamentalists
   - They compare the exchange rate S_t with the fundamental value S^*_t
   - If $S_t > S^*_t$ they will expect the exchange rate to go down towards the fundamental value
   - If $S_t < S^*_t$ they will expect the exchange rate to go up towards the fundamental value
   - This is a negative feedback rule (if a price is too high it is expected to decline, and vice versa)

2. Chartists (technical traders)

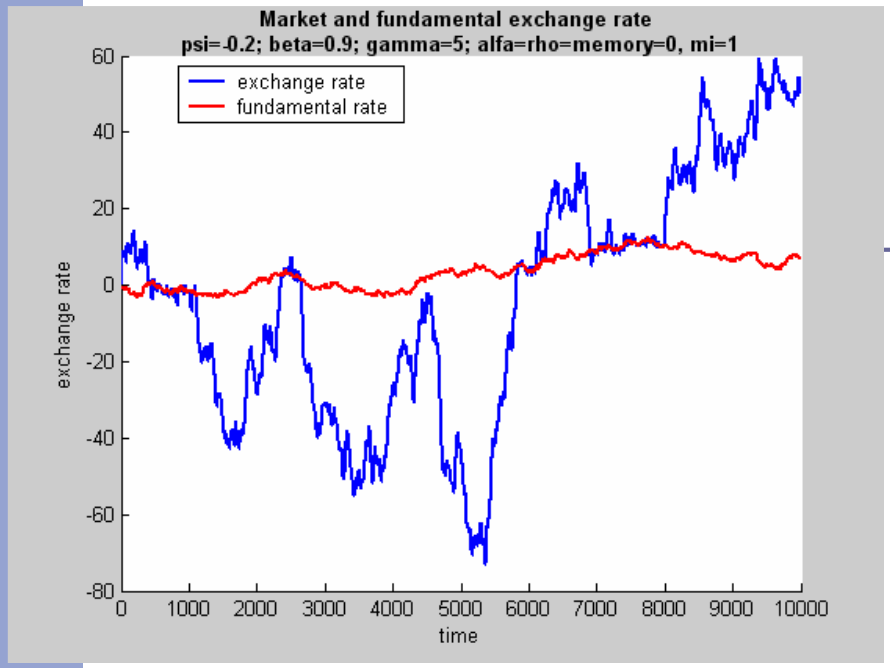
- They extrapolate past exchange rate changes (with intensity beta)
- if the exchange rate has been increasing in the recent past they expect it to continue to increase in the future
- if the exchange rate has been decreasing in the recent past they expect it to continue to decrease in the future

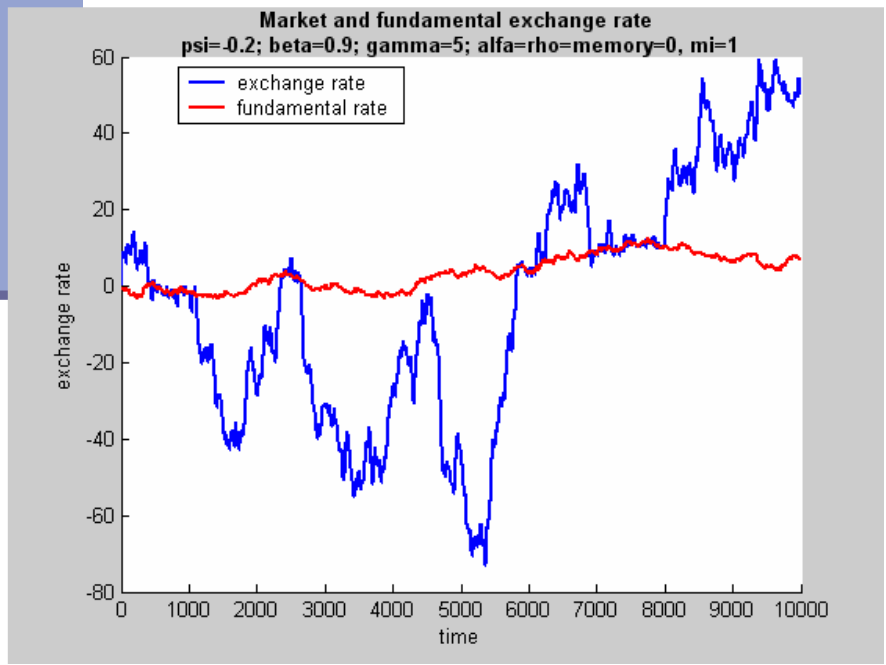
3th block. Learning the forecasting rules: fitness criterion

- Agents choose between the two forecasting rules depending on the profitability of these rules
- Example: if the chartist rule has been more profitable than the fundamentalist rule in the recent past more investors will choose the chartist rule, and less will choose the fundamentalist rule
- In a very uncertain world that agents do not comprehend this is a rational way to deal with uncertainty (“bounded rationality”)

Stochastic simulations

- Non-linear structure of the model does not allow for a simple analytical solution
- We use numerical methods
- We first show some examples of simulations of model in time domain
- Remember: fundamental exchange rate is random walk



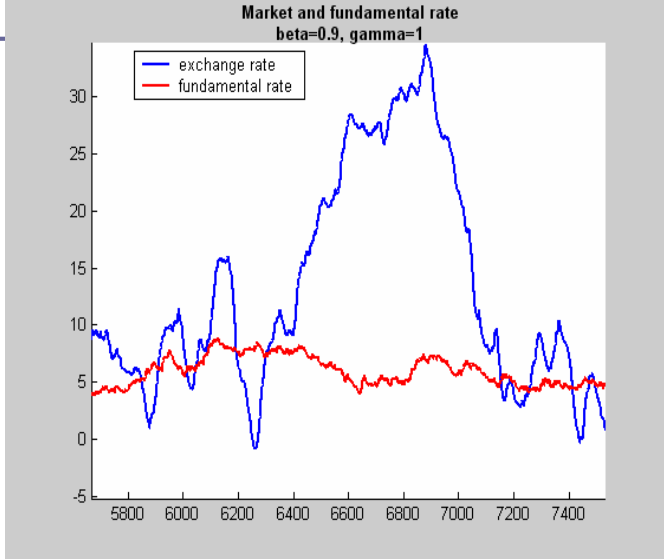


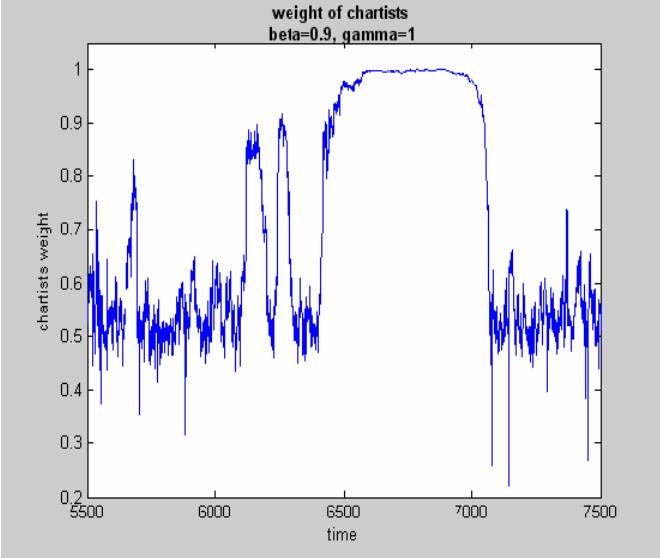
- Model predicts that exchange rate is disconnected from fundamental much of the time
- Periods during which exchange rate closely follows fundamental alternate with periods when exchange rate is disconnected from fundamentals
- The latter are periods during which technical traders completely dominate the market
- It appears that sometimes fundamentals matter at other times they do not.

Model creates bubbles and crashes. The anatomy of bubbles and crashes

- First, self-fulfilling increase in relative profitability of technical trading
- Second, this dynamics reaches its limit when (almost) everybody has become a technical trader.

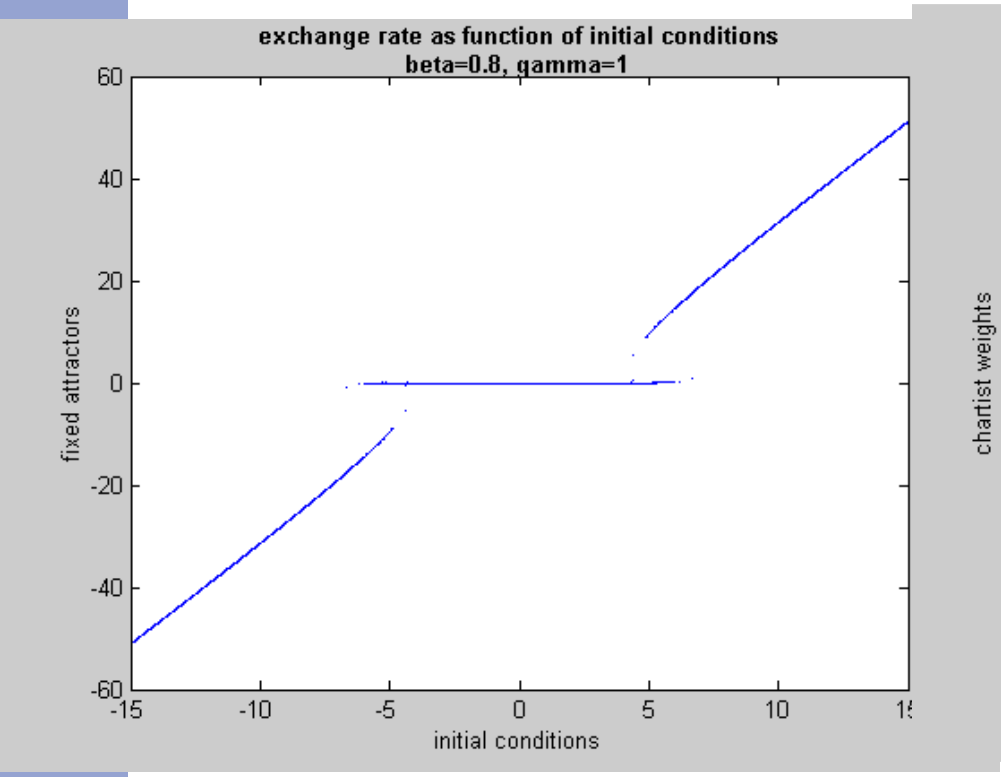
  Technical trading's profitability slows down.
- Third, an exogenous shock, e.g. in the fundamental can lead to a crash
- Technical traders' share is brought back to normal level of tranquil market.
- Asymmetry in bubble and crash

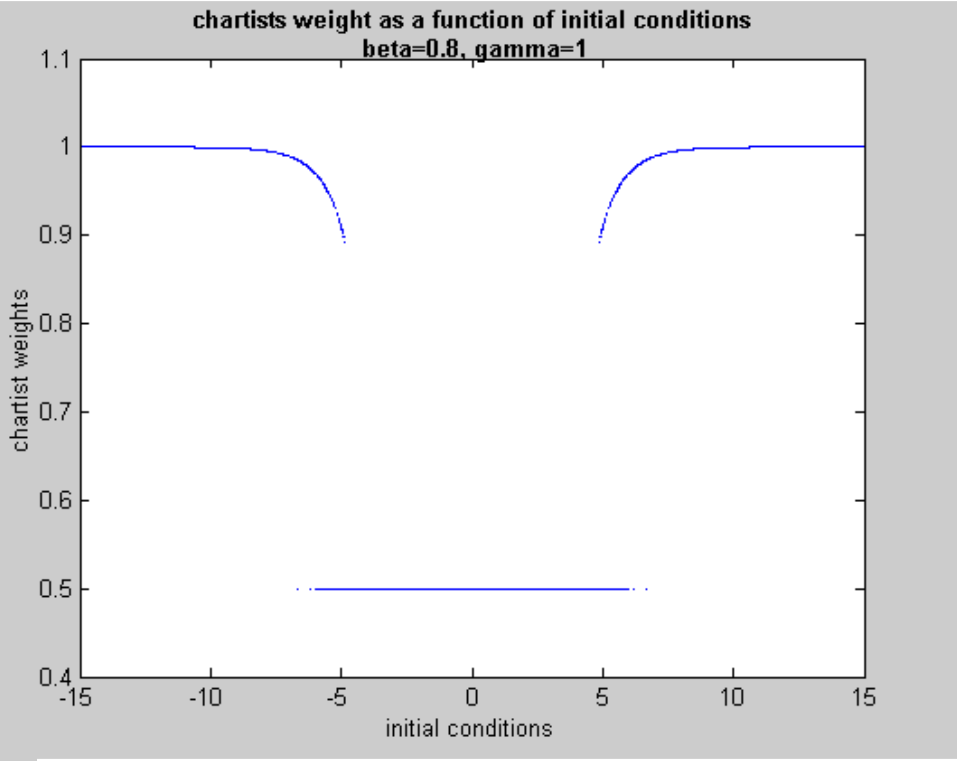




- In order to understand the nature of the results we analyse the deterministic part of the model

Deterministic solution

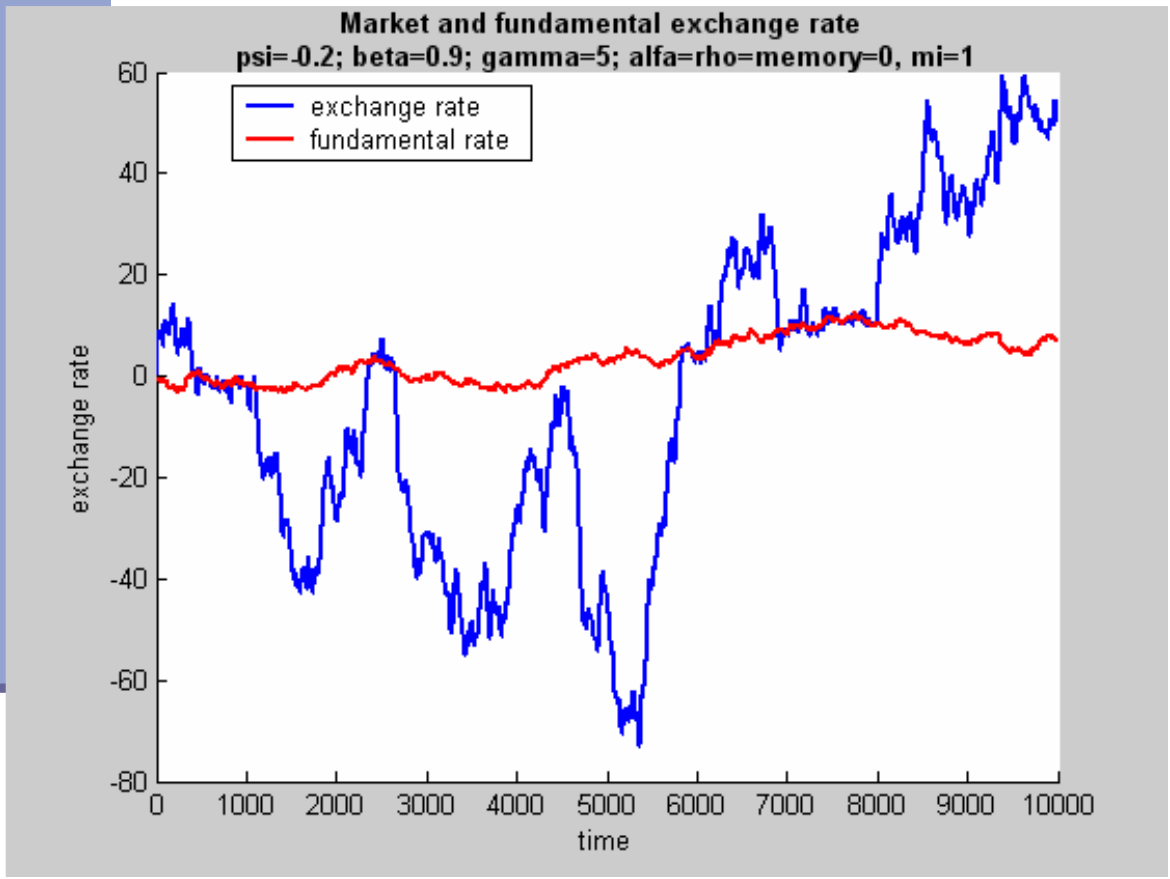




- Two types of attractors.
  - Small disturbance: Fundamental attractor.
  - Large disturbances: Non-fundamental ("bubble") attractors.

- Small disturbances:
  - exchange rate converges to fundamental rate
  - weight of technical traders and fundamentalists are equal to 50%.
  - Their expectations are model-consistent
- For large initial disturbances
  - Exchange rate converges to non-fundamental (bubble) attractor
  - Technical traders' weight converges to 1.
  - Absence of fundamentalists eliminates the mean reversion dynamics.
  - Technical traders' expectations are model-consistent

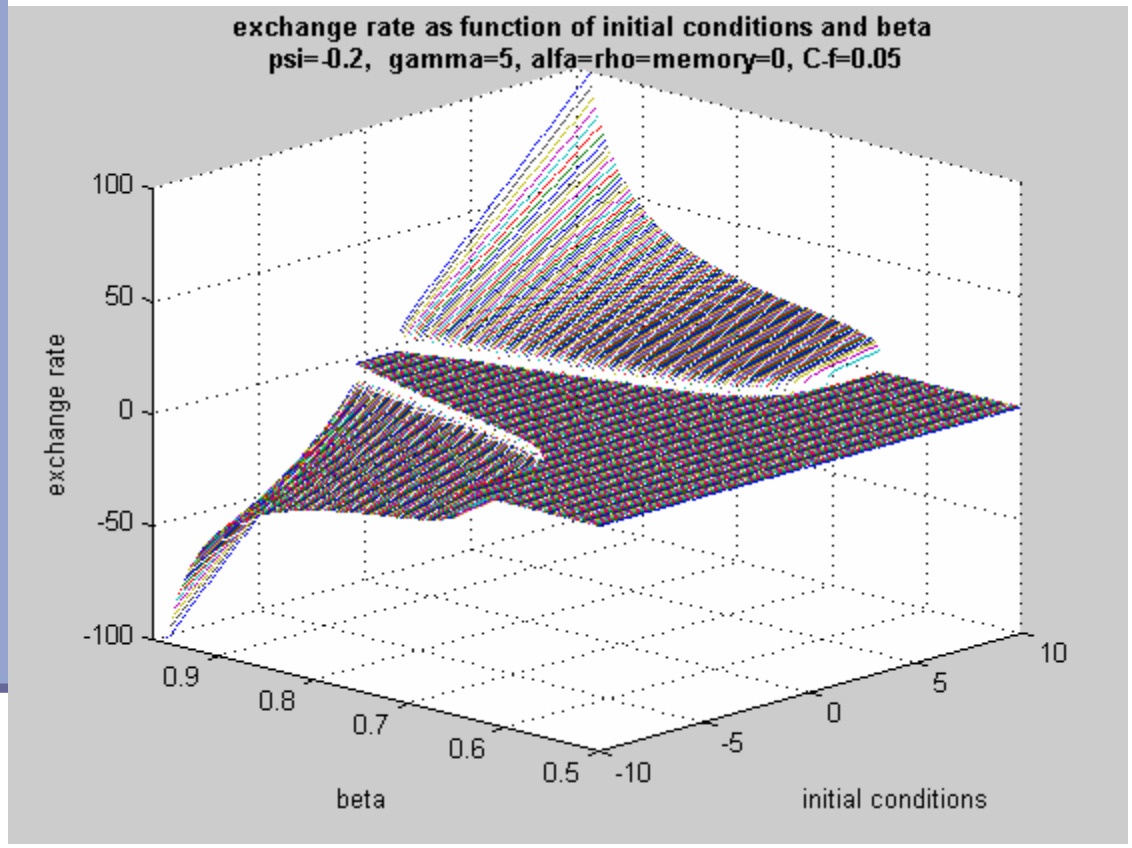
Risk aversion and the nature of equilibria



- When agents have low risk aversion (they perceive risk to be low and the world to be stable) only fundamental equilibria. This is an environment in which agents stick to their beliefs
- When agents have high risk aversion (they perceive risk to be high and the world to be highly uncertain) there are fundamental and non-fundamental equilibria. This is an environment in which agents easily switch to other beliefs (forecasting rules)

- One possible interpretation of these results:
- When fundamentalists are very risk averse, they will not be willing to exploit the profit opportunities that arise when a bubble develops.
- There is a failure of arbitrage
- As a result, the mean reverting forces triggered by fundamentalists are weak and we have many bubbles (and crashes)
- Conversely when fundis have low risk aversion they are willing to exploit these profits during bubble
- Thus bubbles (non-fundamental equilibria) arise because of a failure of arbitrage.

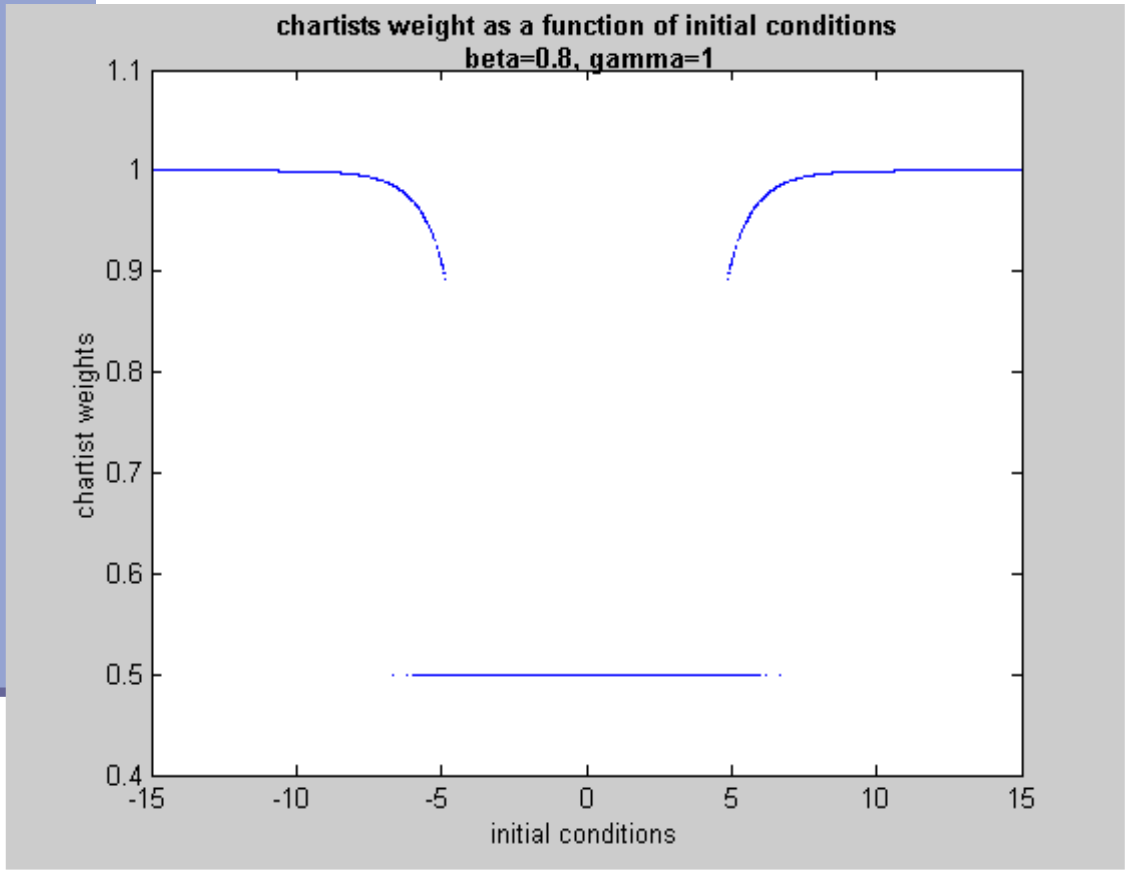
Technical traders' extrapolation and the nature of equilibria



- As beta increases zone of fundamental equilibria shrinks
- Beta measures strenght of extrapolative forecasting
- Smaller shocks lead to bubble equilibria
- Border between fundamental and bubble equilibria is complex (fractal)

Why crashes occur

- It may not be clear yet why bubbles are always followed by crashes.
- Shocks in fundamental are key
- We performed following experiment
  - We fix the initial condition such that it produces a bubble equilibrium
  - We then compute the attractors for different shocks in fundamental



Suppose we are in a bubble equilibrium

Then a sufficiently positive(negative) shock in fundamental brings us back to the fundamental equilibrium (a crash)

Intuition: large displacement of fundamental strenghtens the hand of the fundamentalists

Thus shocks in fundamentals are sources of bubbles and subsequent crash

Basins of attraction around the fundamental steady state: sensitivity with respect to β

Basins of attraction

fundamental

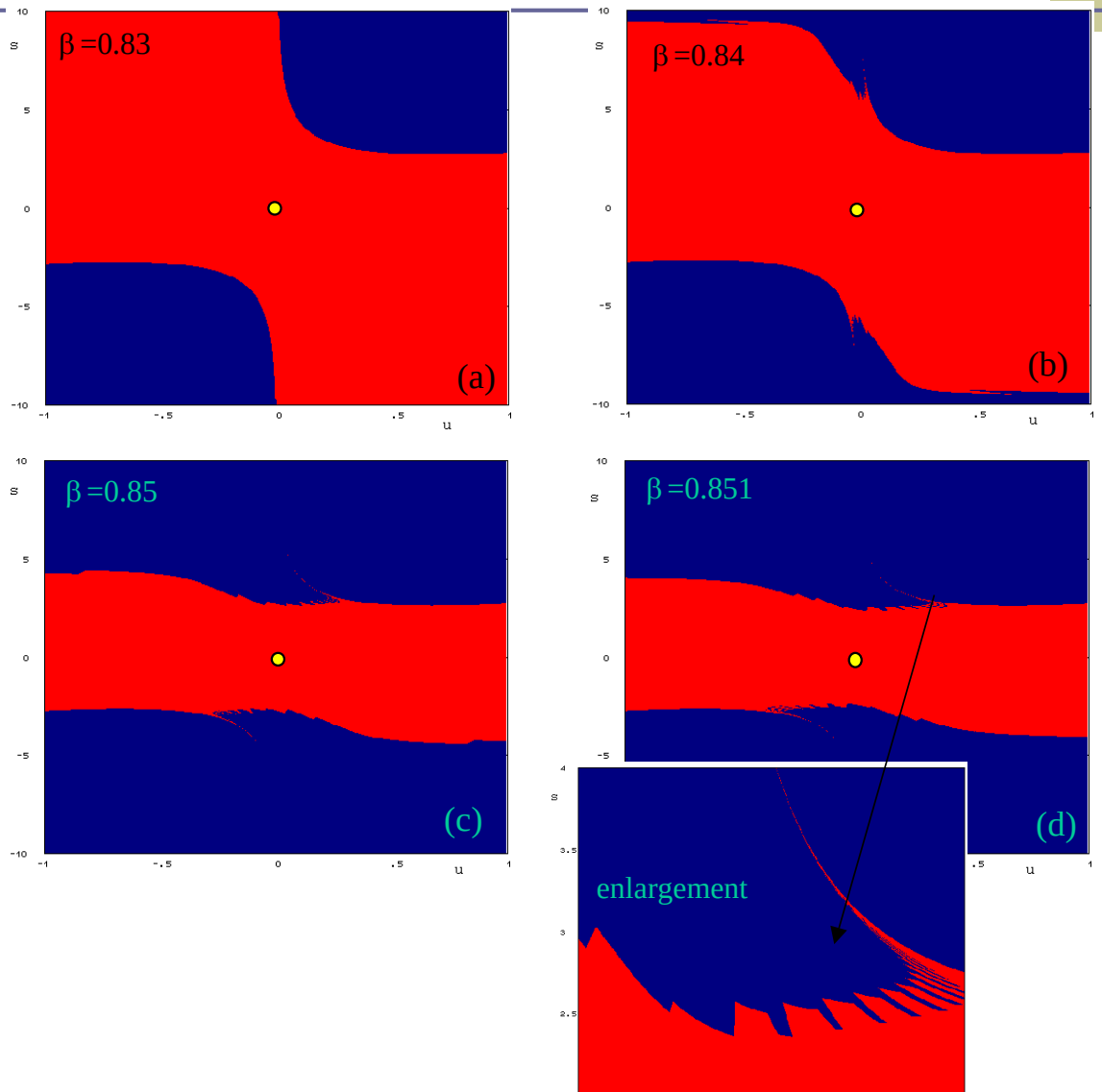
bubble

initial condition

$y_0 = z_0 = 0$ $\sigma^2_{f,0} = \sigma^2_{c,0} = 0.05$ u_0 and s_0 varying

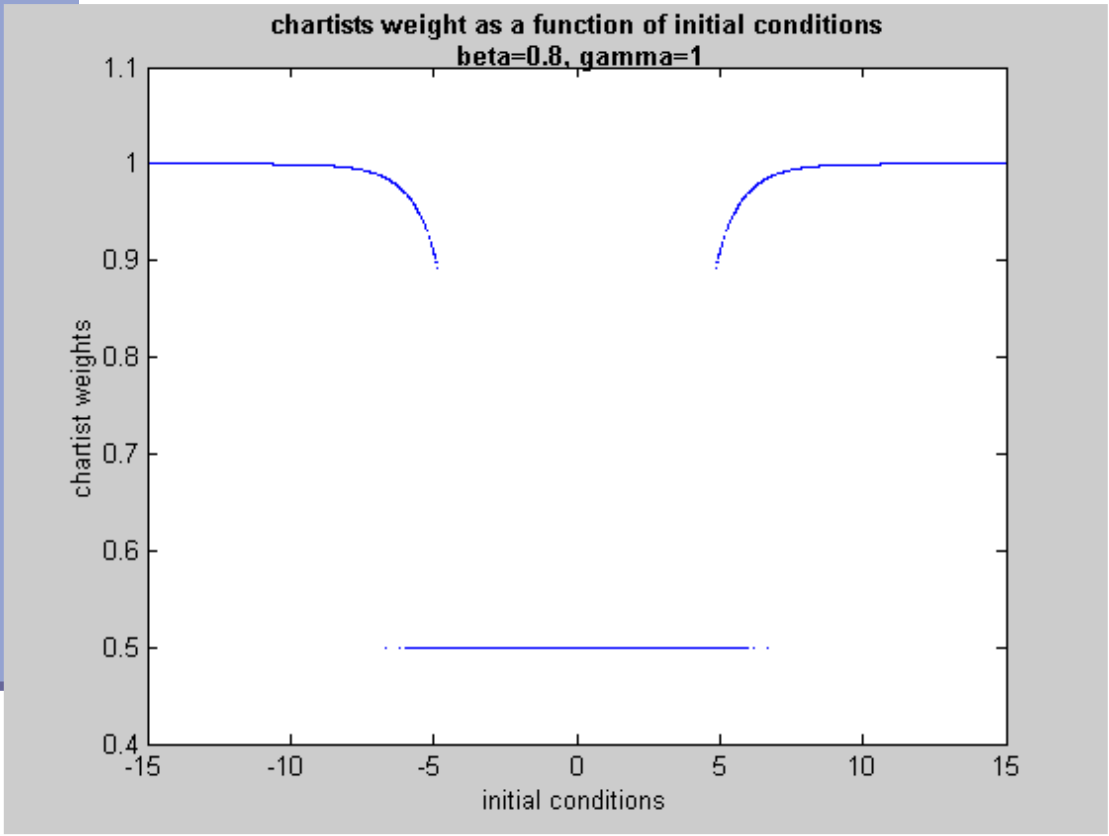
parameters

$\psi = 0.2$ $\mu = 1$ $\gamma = 1$ $\theta = 0.6$



Informational issues

- Agents use simple forecasting rules because they cannot comprehend the full complexity of the underlying model.
- The results of the model suggest that this is the right strategy to follow.
- For despite its simplicity, the model creates an informational environment that is too complex for an individual to understand and to process.
- To show this we analyse the complex boundary between fundamental and bubble equilibria



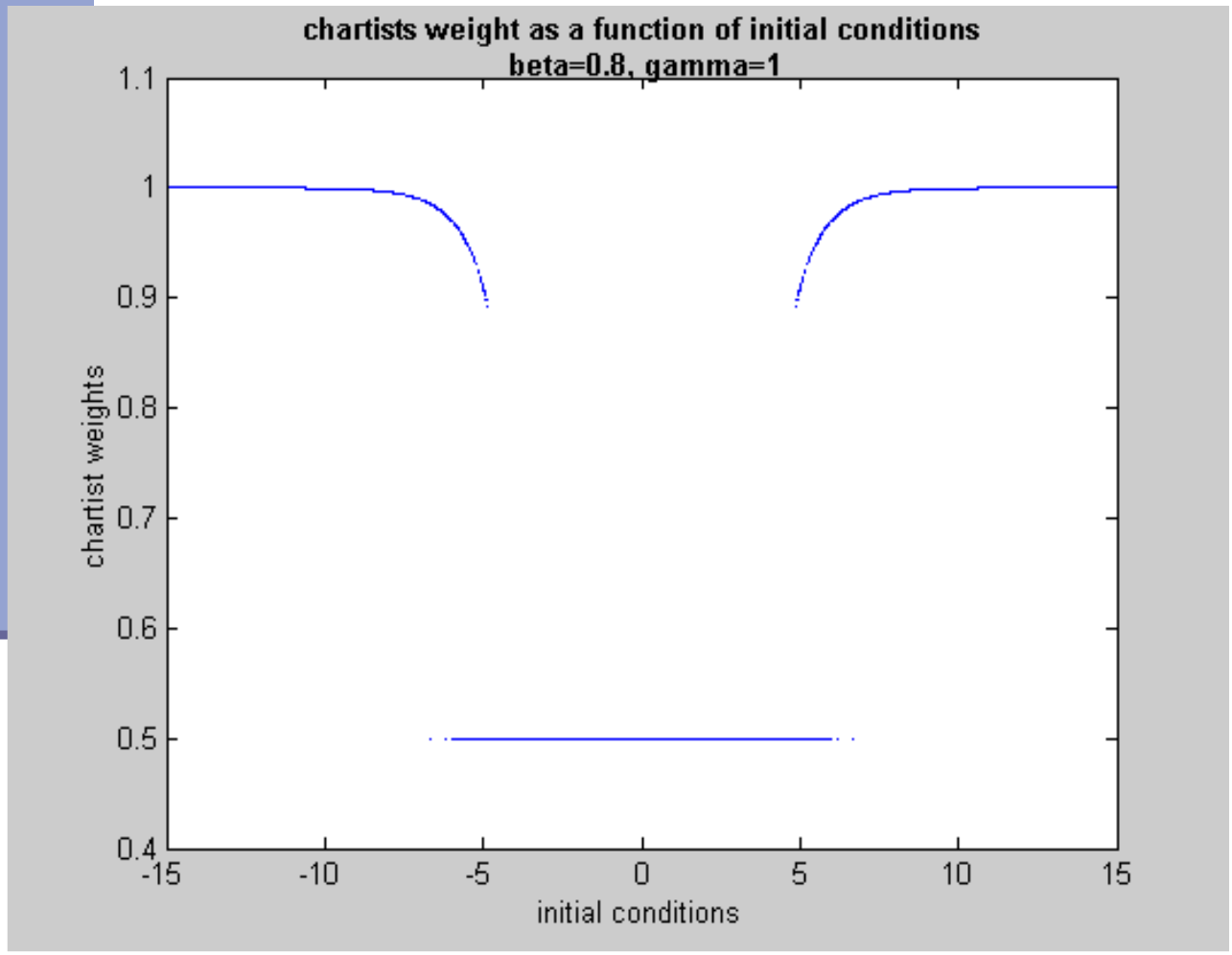
Suppose we know initial condition to be exactly +5

We take a slice from 3D figure in slide 27

Assume the forecaster has estimated beta to be 0.815 with standard error 0.005

Is this enough information to predict whether we move to fundamental or bubble equilibria?

Let's take a blow-up

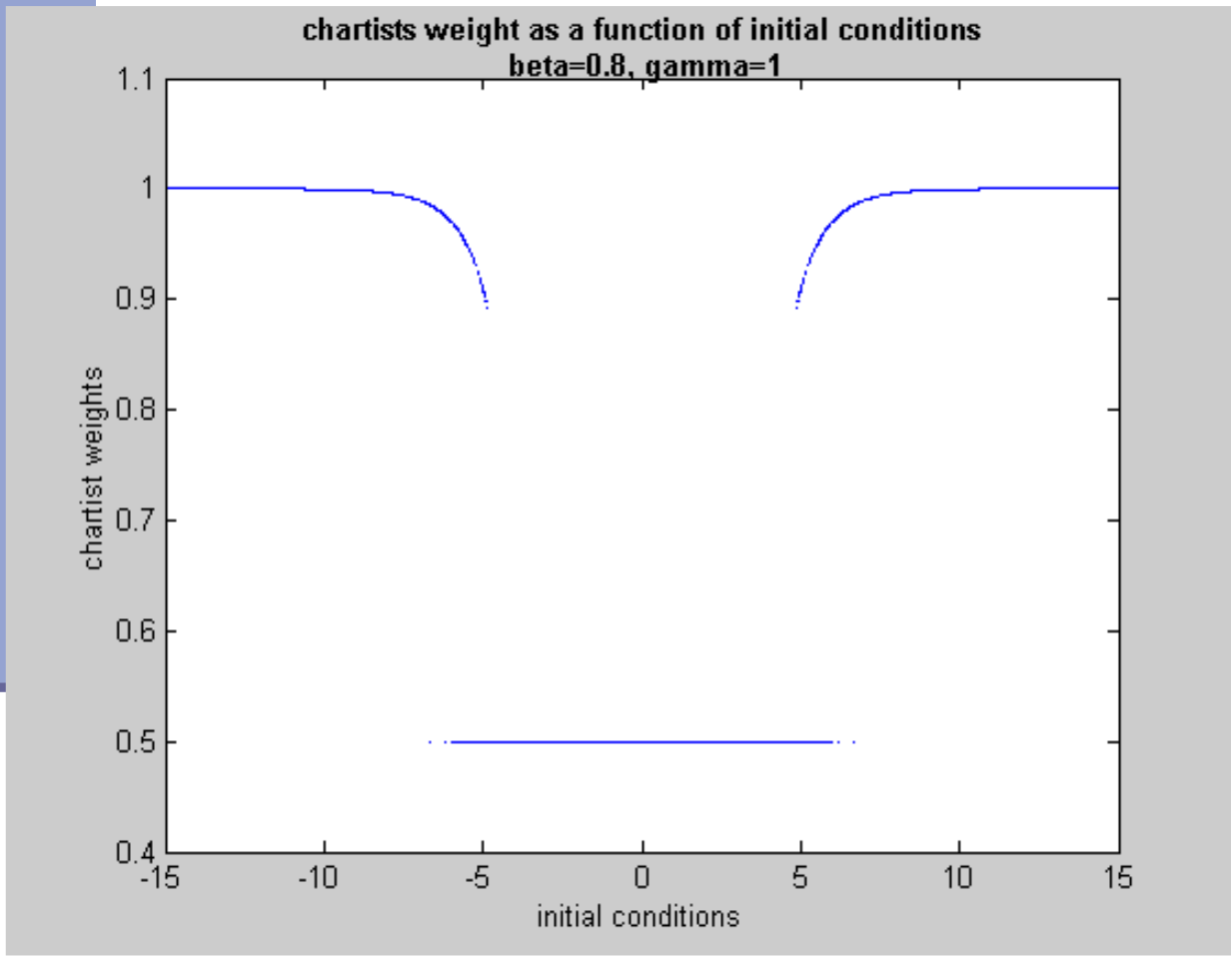


Our forecaster has 23% probability of a fundamental equilibrium, and 77% probability of a bubble equilibrium

Can he improve the precision of his forecast by better econometric techniques?

Suppose that he reduces standard error by factor of 10

We take a new blow-up by a factor of 10



Despite much greater precision of his estimate of beta his precision in forecasting a bubble has not increased at all

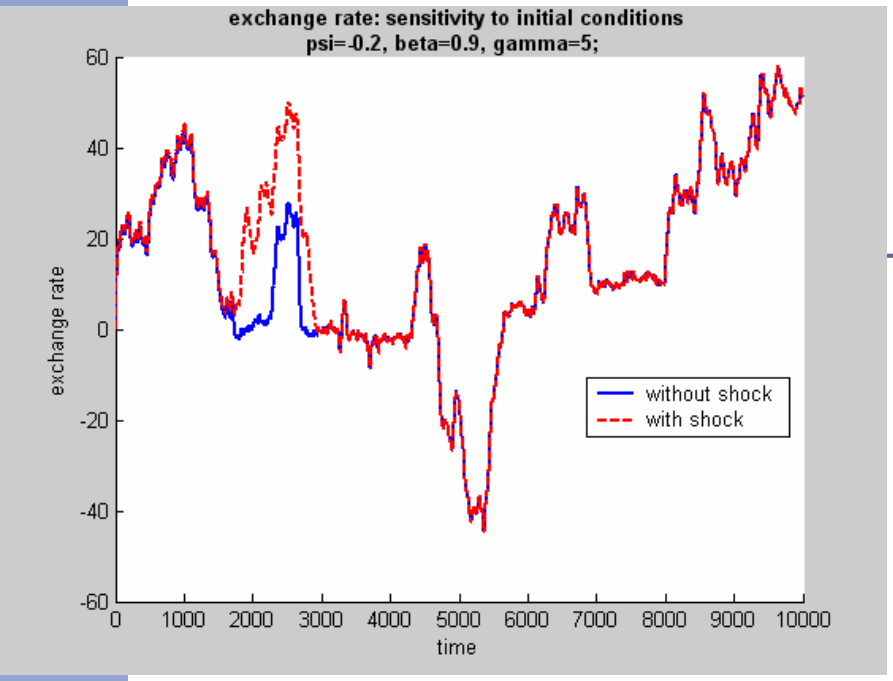
It does not pay to be a good econometrician

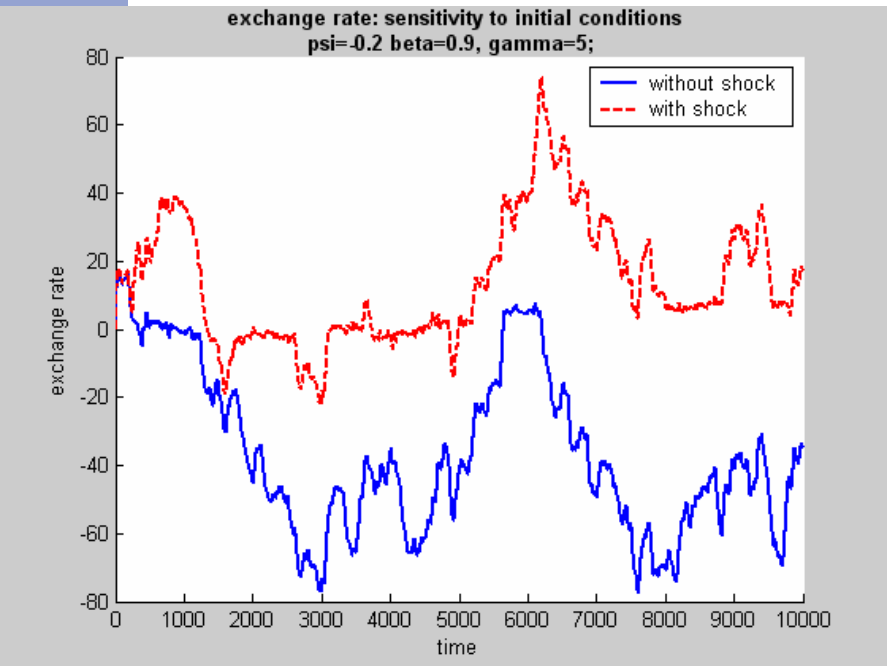
This result has to do with the fractal nature of the border between the bubble and fundamental equilibria

- Thus, even in a very simple model agents face enormous informational problems, that they cannot hope to solve.
- As a result, agents will not attempt to use all the information provided by the underlying structural model.

Sensitivity to initial conditions

- The fractal nature of the boundary between fundamental and non-fundamental equilibria produces a potential for sensitivity to initial conditions





We simulate the model twice with exactly the same realization of the fundamental variable

Only initial conditions differ slightly, i.e. +0.1

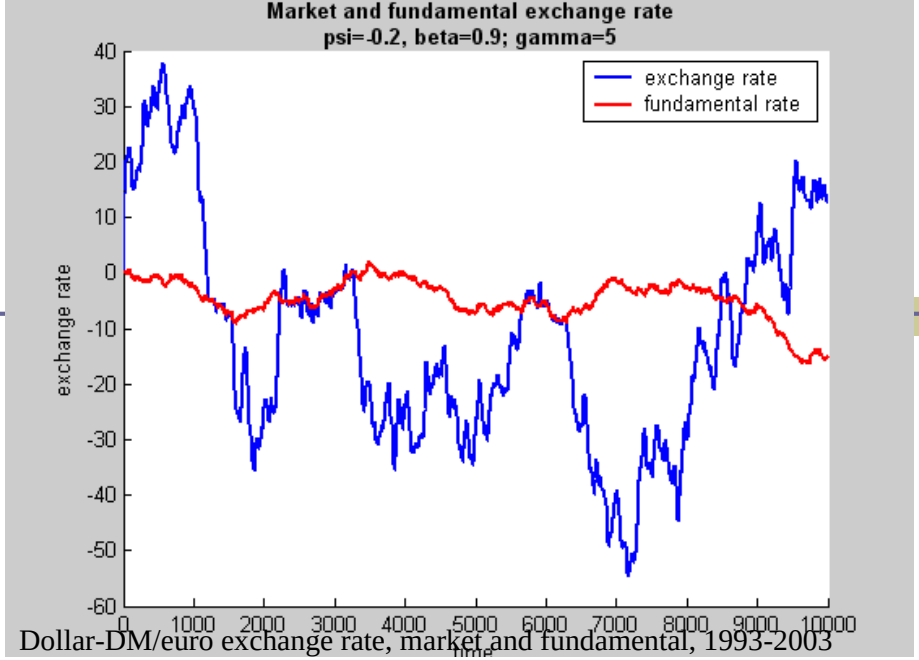
Empirical relevance of behavioral model

Empirical relevance of model

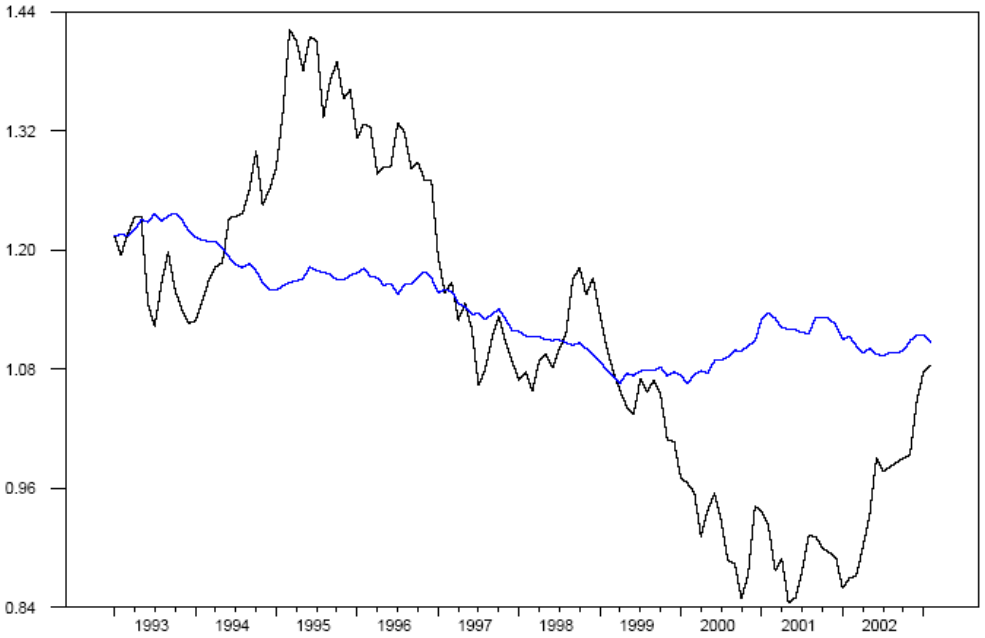
- We calibrate the model in such a way as to mimick main empirical regularities
  - Disconnect puzzle
  - Excess volatility

Disconnect puzzle

- The major puzzle in exchange rate economics
- Our model mimicks this puzzle



Dollar-DM/euro exchange rate, market and fundamental, 1993-2003

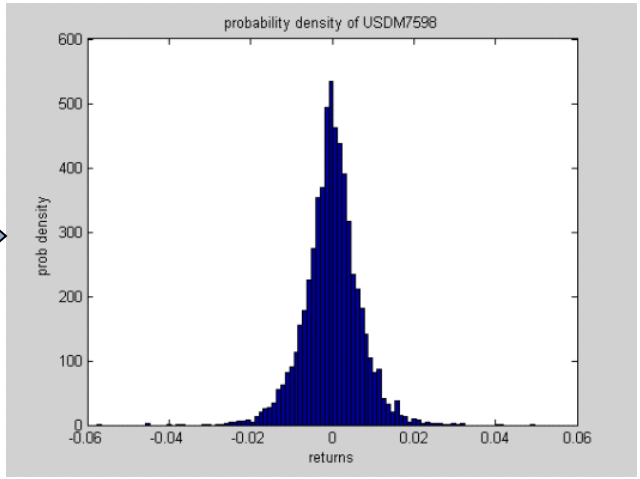


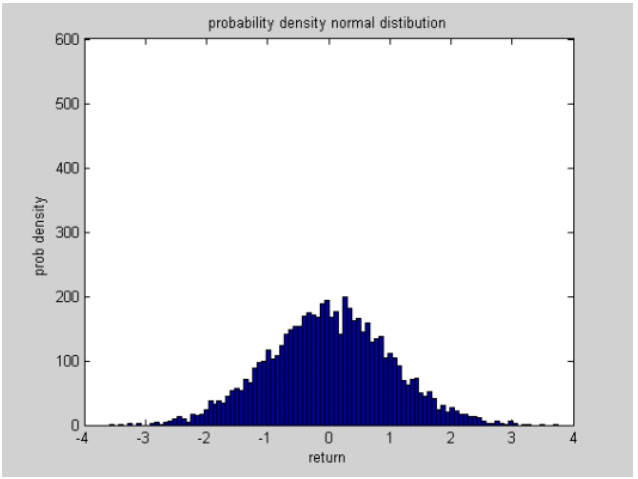
Source: Ehrmann, M., and Fratzscher, M., Exchange Rates and Fundamentals: New Evidence from Real-time Data, forthcoming in Journal of International Money and Finance, 2004

Returns have fat tails and excess kurtosis

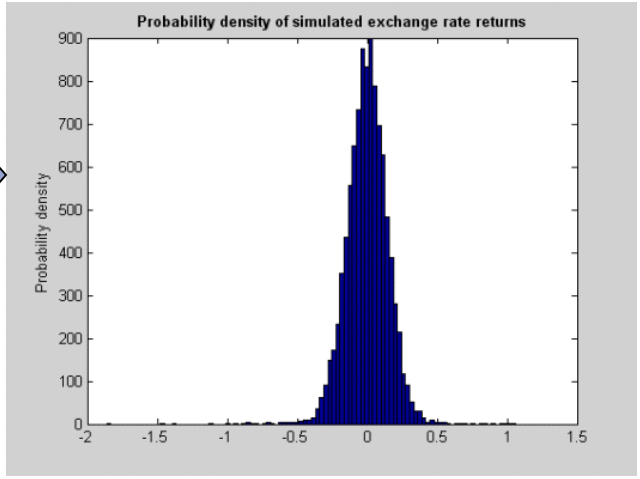
Normal distribution

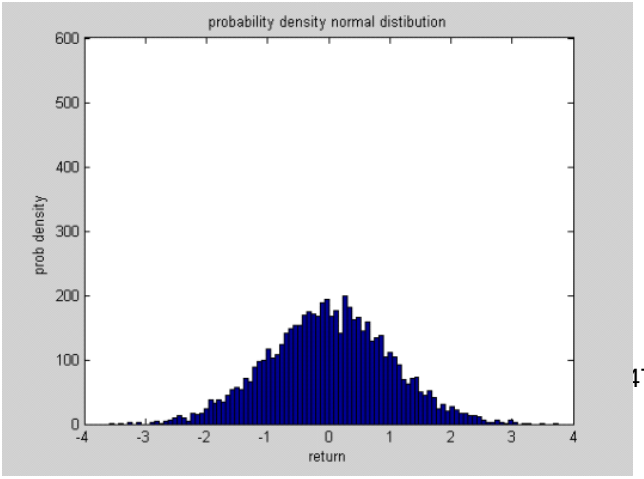
Real life distribution of returns

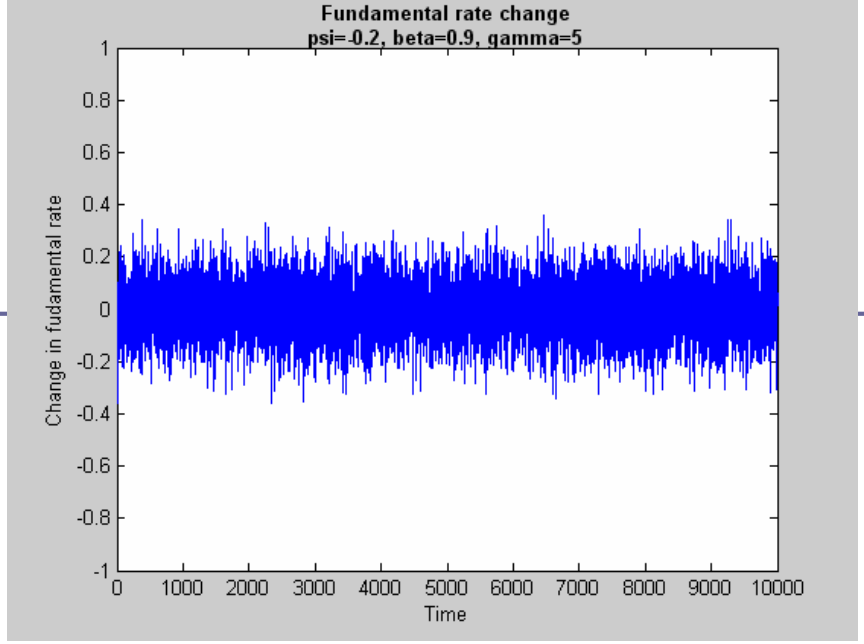




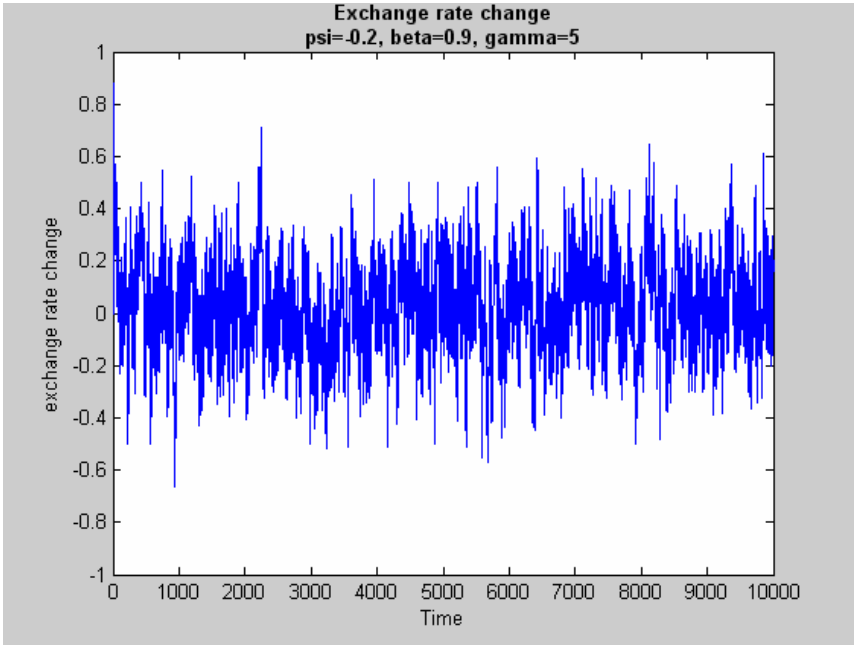
Simulated distribution of returns






Fundamental rate change
psi=-0.2, beta=0.9, gamma=5
Change in fudamental rate
Time
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

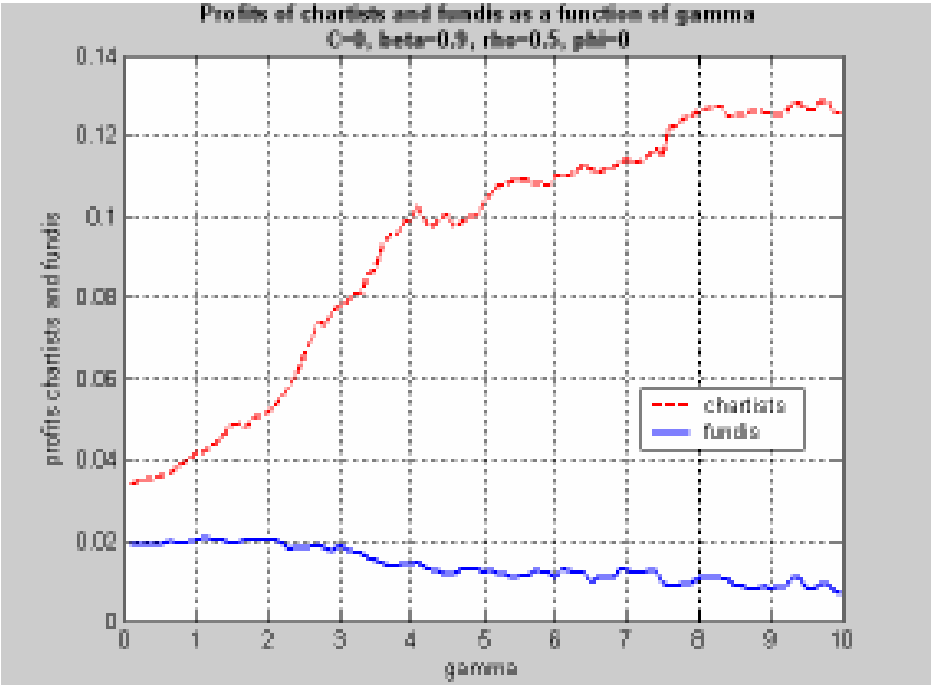
(a)

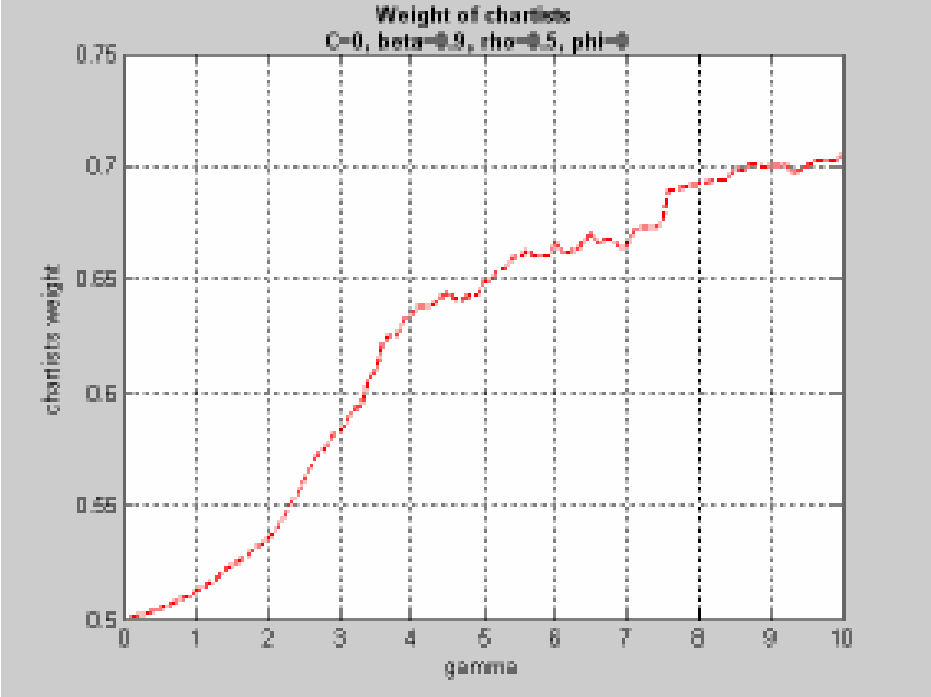

Exchange rate change
psi=-0.2, beta=0.9, gamma=5
exchange rate change
Time
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

(b)

Is chartism evolutionary stable?

- Traditional analysis is scornful about chartism and technical analysis
- In the REEM model there is no place for these rules.
- Reality is that technical analysis is widely used, in fact more so than fundamental analysis
- Can our model replicate this empirical observation?

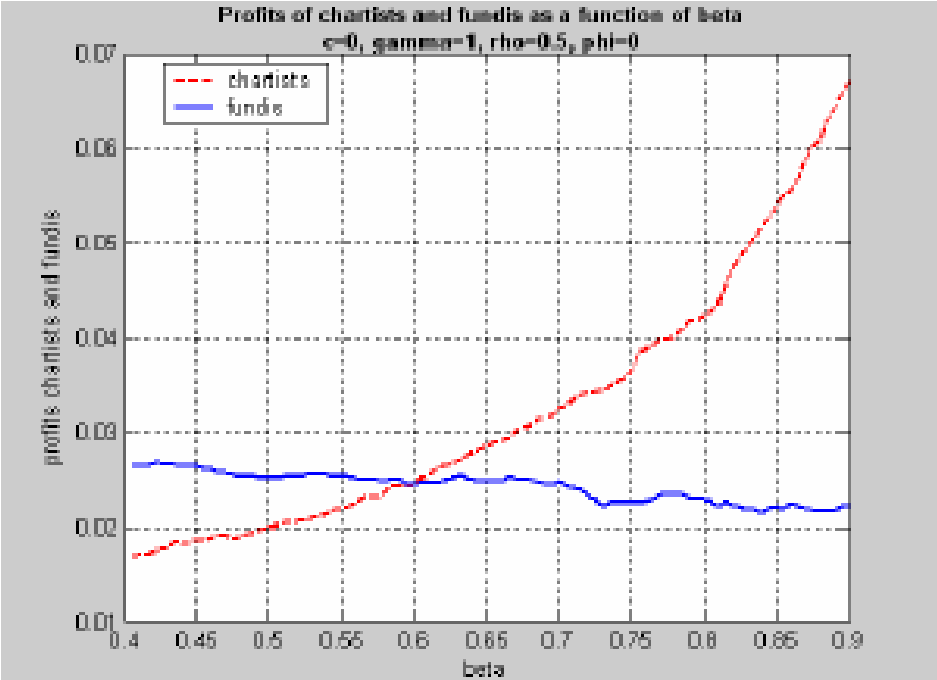


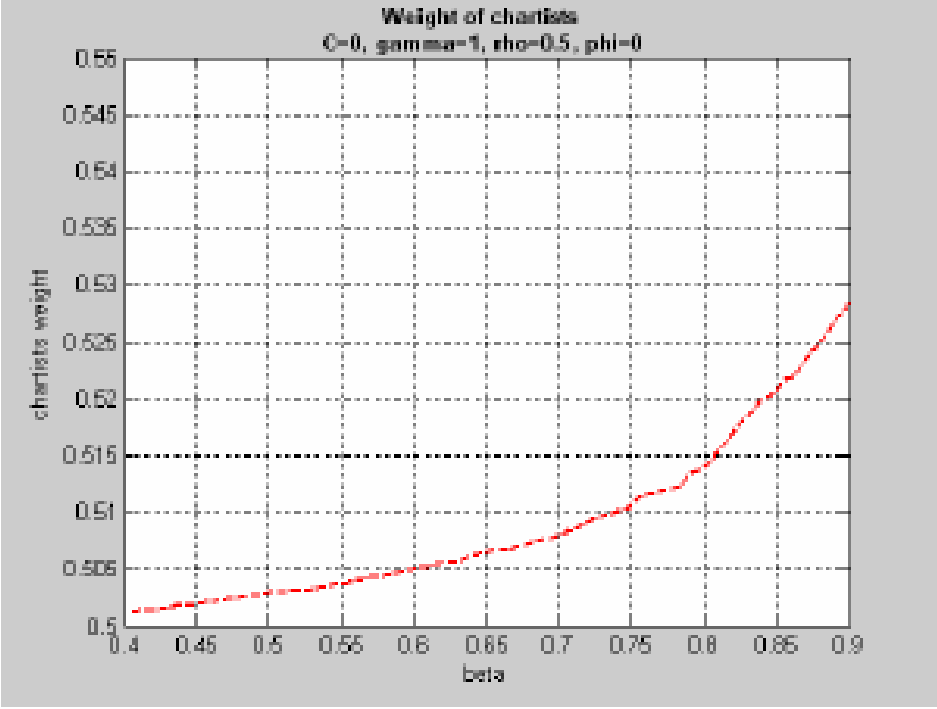


We compute the profitability of chartist and fundamentalist rules

Profitability of chartist rules increases with gamma

Weight of chartists increases with gamma

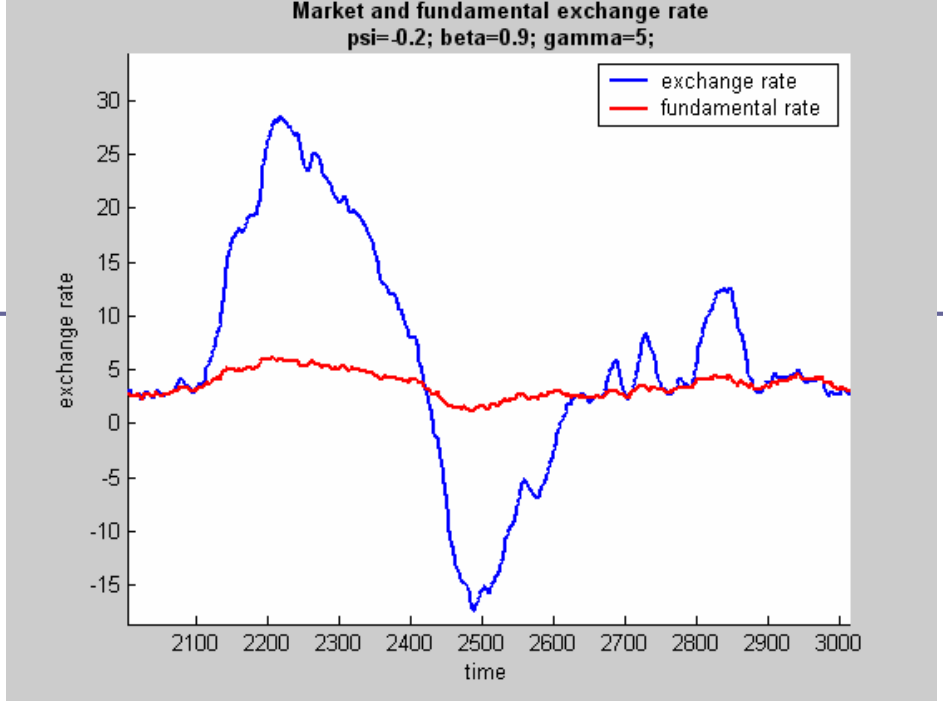

Profits of chartists and fundis as a function of beta
c=0, gamma=1, rho=0.5, phi=0
chartists
fundis
profits chartists and fundis
beta
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9


Weight of chartists
C=0, gamma=1, rho=0.5, phi=0
chartists weight
beta
0.5
0.505
0.51
0.515
0.52
0.525
0.53
0.535
0.54
0.545
0.55
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9

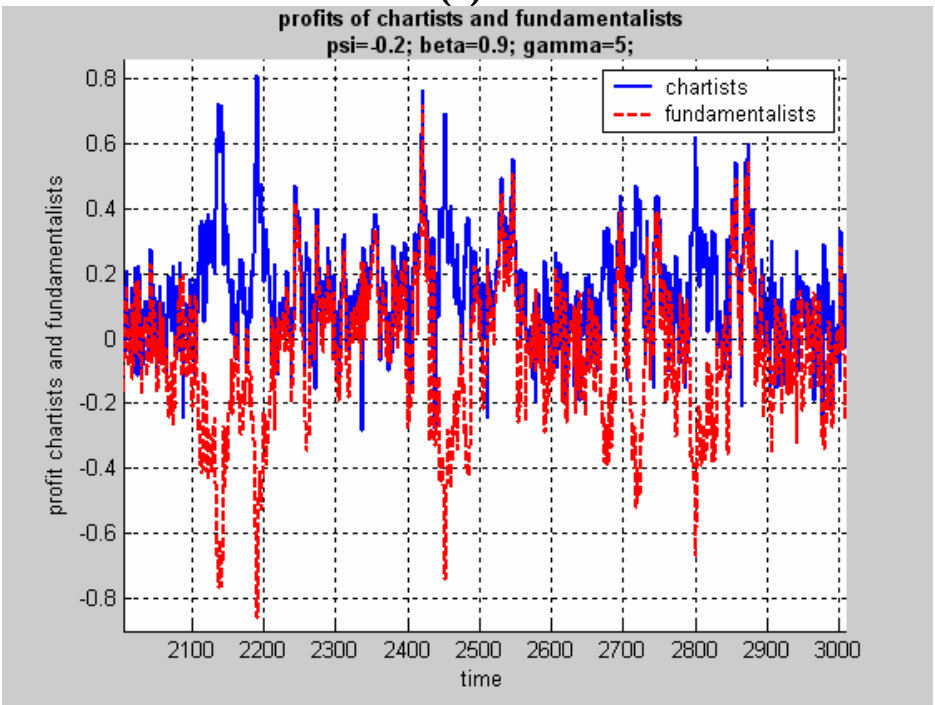
Some results are noteworthy.

- Chartist forecasting rules turn out to be more profitable than fundamentalist rules for most parameter values,
- leading to systematically larger share of chartism (technical trading) compared to fundamentalism.
- We observe this in reality

- This result is related to the fact that as these parameters increase, the probability of the occurrence of bubbles increases.
- Chartist forecasting rules become more profitable in an environment of turbulence during which the exchange rate deviates from its fundamental.



(a)



During bubbles chartists make dramatically more profits

Fundamentalists make major losses; that's why they drop out of the market during bubbles

- Fundamentalist rules appear to be loss making on average.
- Does this mean that instead of chartists, the fundamentalists are in danger of extinction?
- We measure the profitability of forecasting **rules**.
- During the bubble phases the use of chartist rules is very profitable while the use of fundamentalist rules is loss making.
- As a result, most agents switch to the use of chartist rules and few if any agents continue to use fundamentalist rules during these bubble phases.

Implications for forex interventions

- Mainstream view: only unsterilized intervention is effective
  - Because it changes the money supply and the inerest rate
- Sterilized intervention has no effect
- Not so in behavioural model
- Reason: by intervening the central bank adds mean reversion in the market
- And strengthens the fundamentalists
- It also makes fundamentalism more profitable

Conclusion

- The world we have modelled is one in which agents do not understand its complexity
- Therefore they use simple rules of behaviour
- which they check ex post (fitness criterion)
- This is the way to introduce discipline into the model
- In such a world we get a very different dynamics compared to rational expectations world

Conclusion

- Nature of the dynamics
  - There are bubble equilibria that attract the asset prices
  - They will be reached as a result of shocks which makes extrapolating forecasting profitable
  - Sensitivity to initial conditions, or the importance of trivial events

- Once in a bubble equilibrium one can stay there for a long time … or for a very short time
- As a result, asset price is disconnected from fundamentals very often.
- The switch from one regime to the other creates turbulence