Decision Dynamics via Coupled 2-D Map

Yun Tao

- Motivation
- Empirical basis
- Mathematical model
- Python simulation
- Future development

Why bother?

- Population biology
  - Spatial ecology
  - Behavioral ecology
  - Population dynamics
  - Evolution
- Economics
- Sociology
  - Global commons
- Future models require:
  - State-dependency
  - Past-dependency (memory)
  - Rationality
  - Information flow
  - Suboptimality

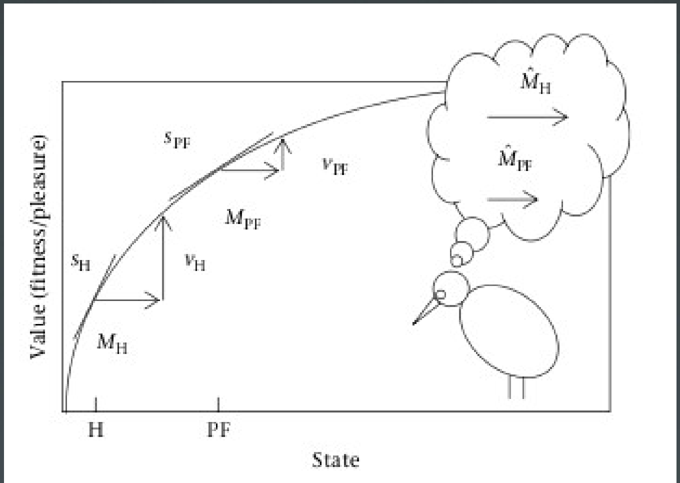
Decision dynamics

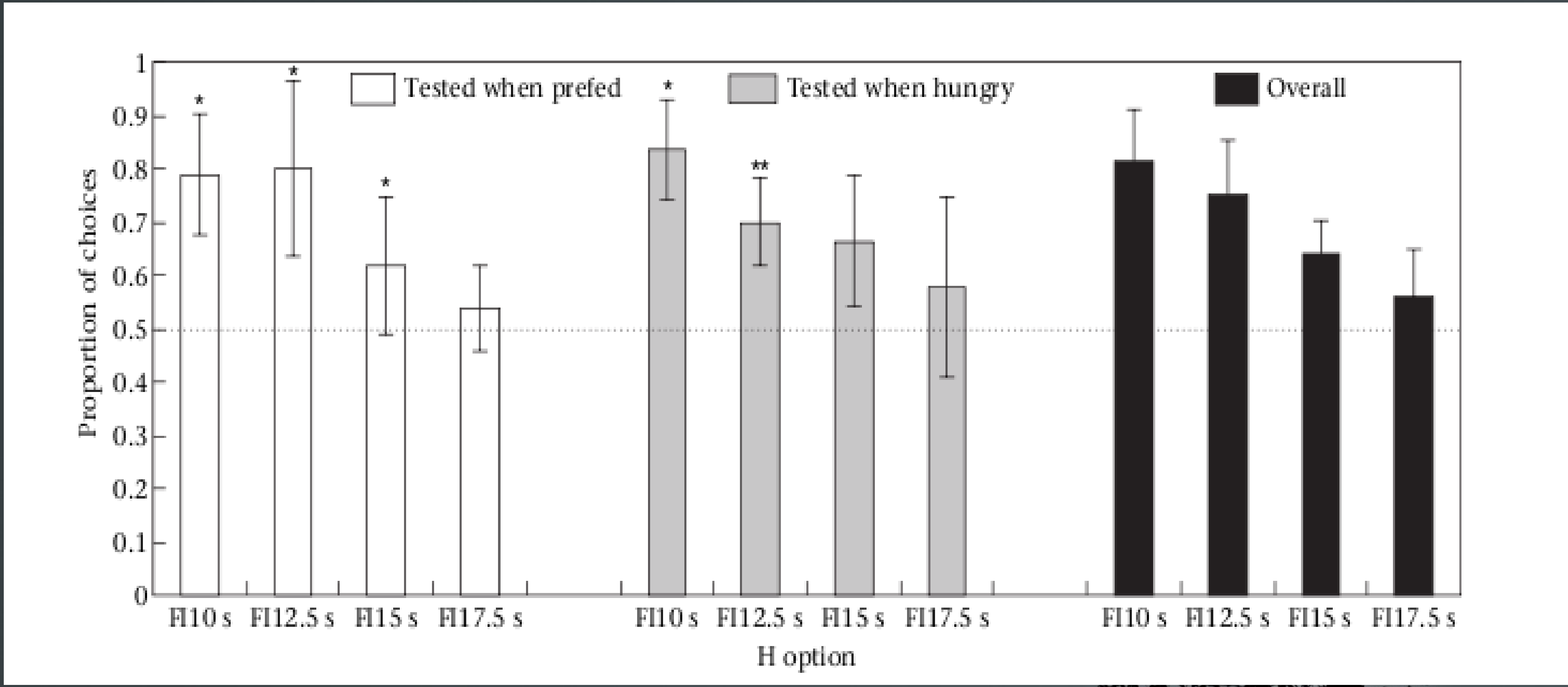
- Tradeoff
  - Rewards/Strategies
  - 'Commitment' cost - Time/Fitness-related variable
  - * Preference*

Case study

- Two Food options of equal 'intrinsic' value
- Trained under hungry/prefed conditions
- Test for preference under both conditions

In a nut shell..





In other words..

$\omega:$ *intrinsic option value*
$\nu:$ *fitness gain*
$E:$ *agent weariness*
$S:$ *agent satiation / activeness*
$\delta:$ *metabolic decay*
$\epsilon:$ *chance of occurrence*
$\beta:$ *suboptimal preference*
$\varphi:$ *impatience exponent*

$$\text{if } \omega_t = \omega_t^p$$

$$E_{t+1} = E_t e^{\delta(1-E_t)} - \epsilon_t \omega_t$$

$$\beta_{t+1} \approx 0$$

$$\text{else}$$

$$E_{t+1} = E_t e^{\delta(1-E_t)} - \epsilon_t \omega_t \beta_t$$

$$\beta_{t+1} = \beta_t e^{\varphi}$$

Memory Box

$$For\ each\ \epsilon_t = 1,$$

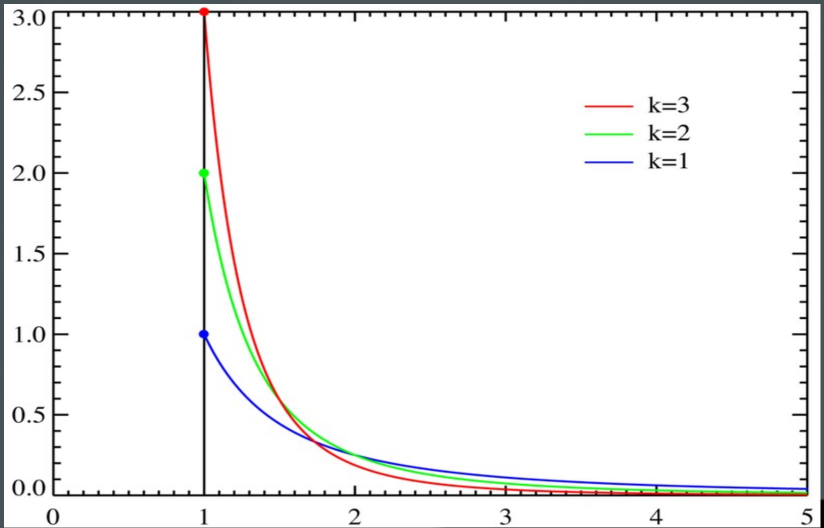
$$\omega_t = pareto.rv(k_t)\zeta\ ,\ k_t = f(E_t)$$

$$\{\omega_t\}_{t\geq 0} \rightarrow storage$$

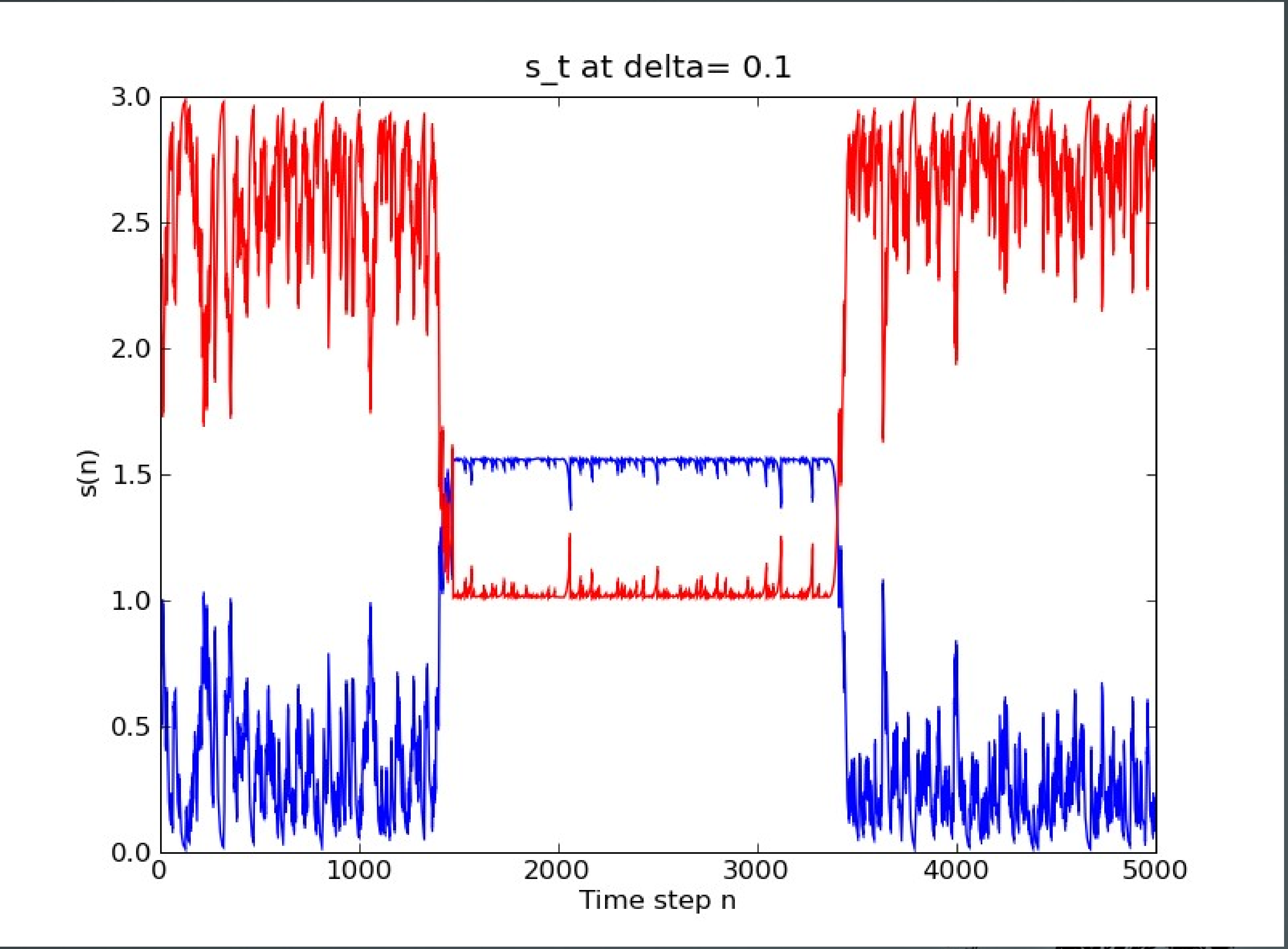
$$\nu_t = \sin(S_t + \omega_t) - \sin(S_t),\ S_t = \frac{\pi}{2} - E_t$$

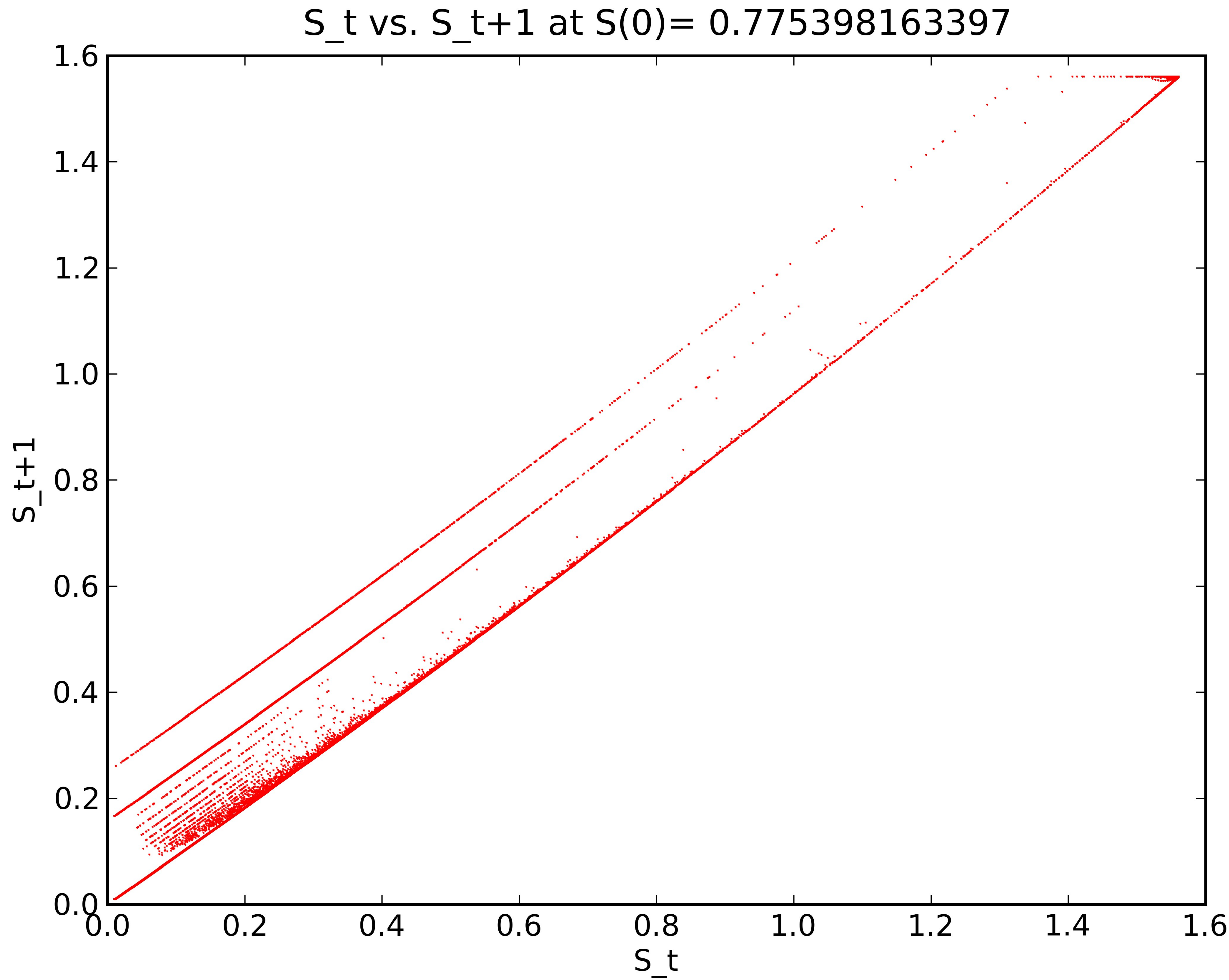
$$\{\nu_t\}_{t\geq 0} \rightarrow storage$$

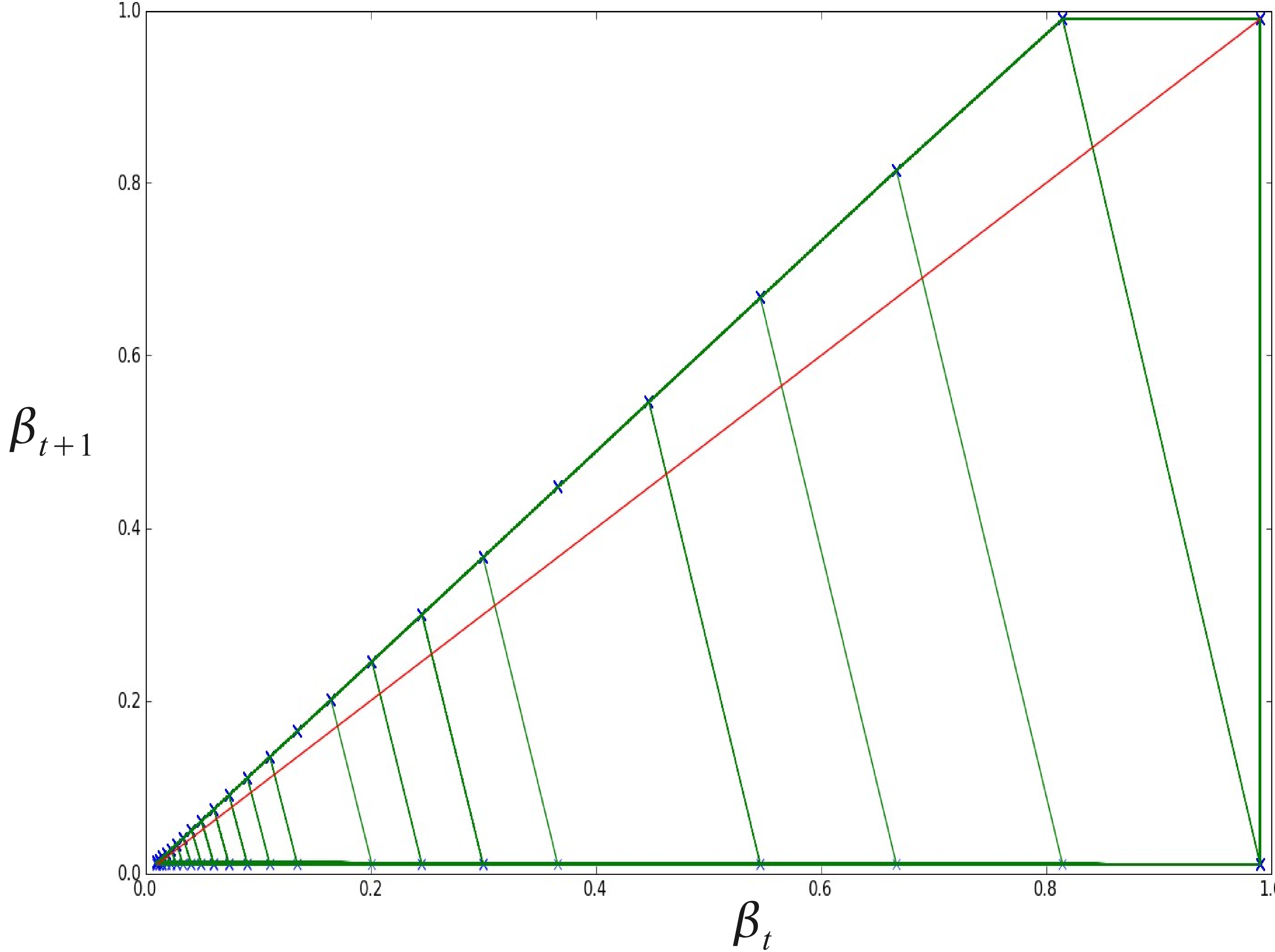
$$\omega_t^p = \{\omega_t : \nu_t = max\{\nu_t\}_{t\geq 0}\}$$



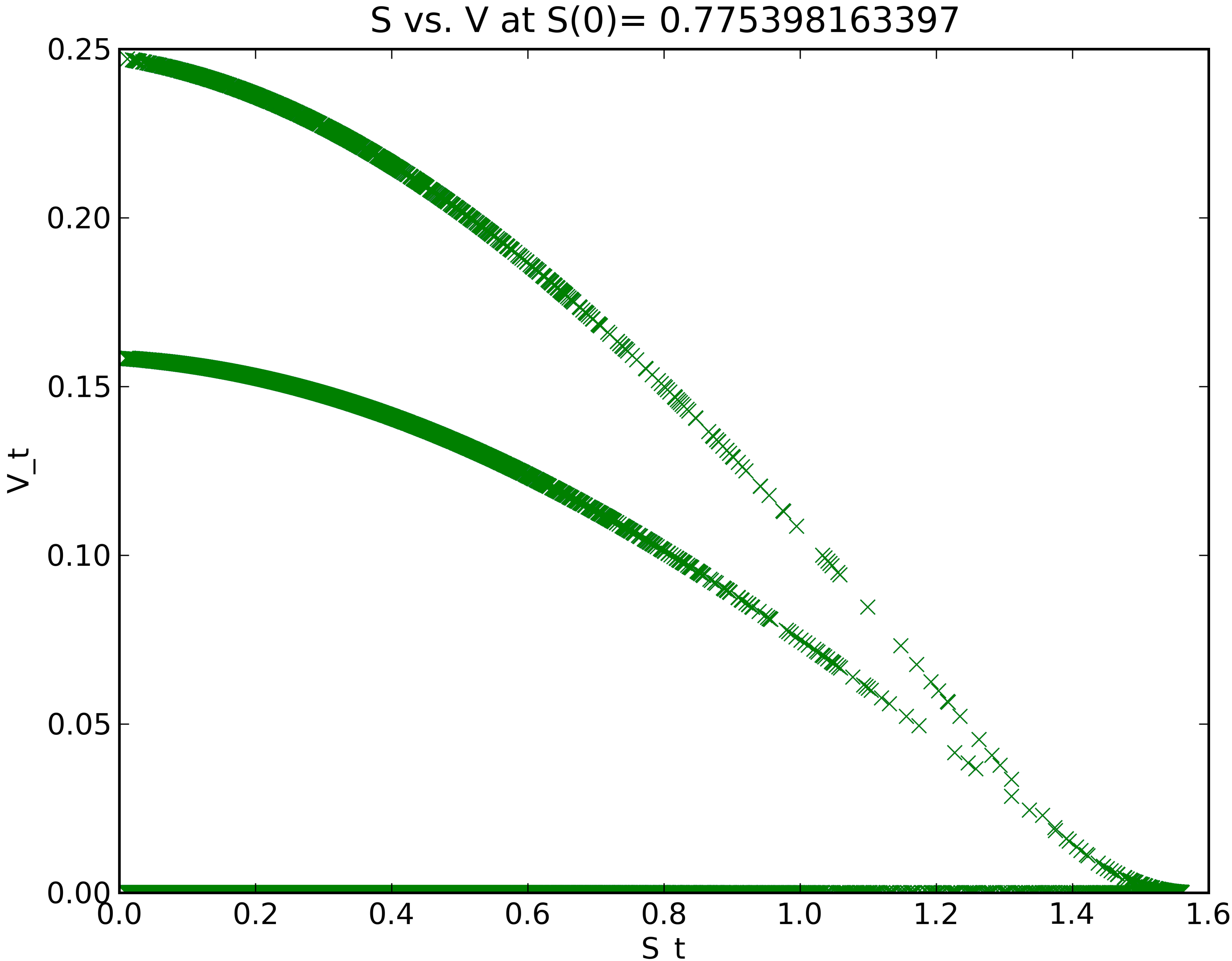
Python it up!!


s_t at delta= 0.1
s(n)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
1000
2000
3000
4000
5000
Time step n

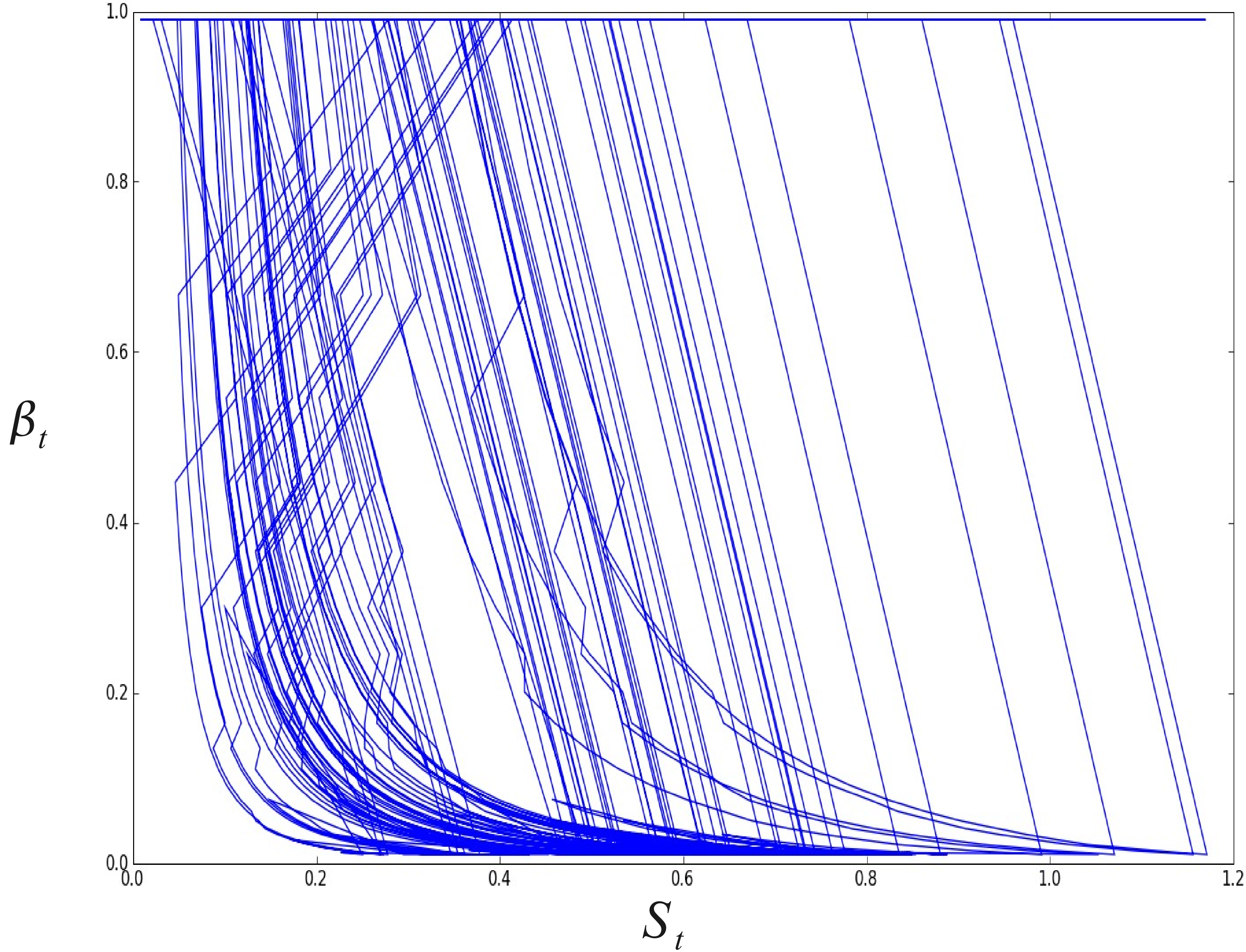

S_t vs. S_t+1 at S(0)= 0.775398163397
S_t
S_t+1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6



β_{t+1}
β_t
0.0
0.2
0.4
0.6
0.8
1.0



S vs. V at S(0)= 0.775398163397
V_t
S_t
0.00
0.05
0.10
0.15
0.20
0.25
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6



1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
β_t
S_t

Still so much more to do..

- Tranlate to continuous system
  - Options + time
- Incorporate rationality
  - Expected commitment
  - Environmental assessment
  - Future prediction
  - Learning
- Relate to game theory
- Multi-dimensionality
- Greater realism in behavioral response
  - Benefit delay
  - Parametric state-dependence
  - Memory loss/gain through repetition
  - Choice-locking
- Stability analysis
- Scaling law present?