Scientific Computing in Economics and Finance
Past, Present and Future

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What do economists do?

- Set interest rates at the BOJ
- Forecast tax revenues / assess policy changes
- Study competition policy (e.g., mergers, monopolies)
- Study pension plans
- Study the determinants of long run growth
- Study the impact of COVID / COVID relief policy

Example. What will be the impact of a 100BPS $\uparrow$ in the federal funds rate on unemployment in one year?

Is economics a science?

The goal of the scientist is to comprehend the phenomena of the universe that he observes around him.

To prove that he understands he must be able to predict.

To predict quantitatively one must have a mechanism for producing numbers.

This necessarily entails a mathematical model.

– Richard Bellman (1920 – 1984)

So what is economic science?

Why is economics different to astrophysics, chemistry, etc.?

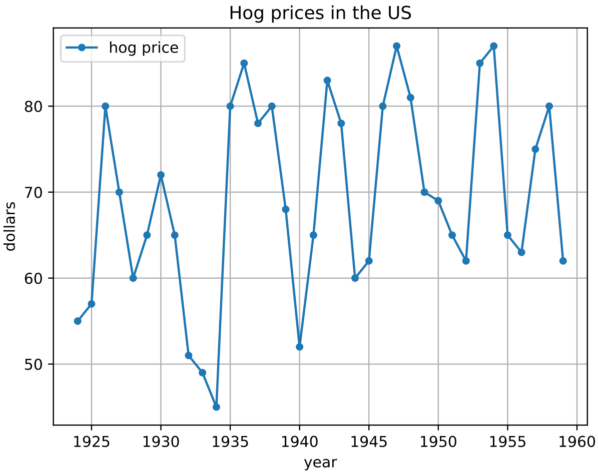
- Economic outcomes depend on human choices
- Human choices depend on beliefs, incentives, etc.
- Economic processes are nonstationary (no immutable laws)

Example. The Lucas critique: it is naive to try to predict the effects of a change in economic policy entirely on the basis of relationships observed in historical data

Extended example: the cobweb model

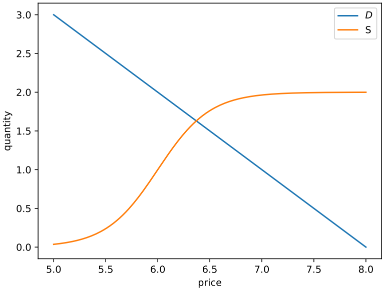
An “old” economic model

- Benner (1876)
- Haas and Ezekil (1926)
- Ricci (1930)
- Kaldor (1934, 1938)
- Ezekil (1938)
- Rosen, Murphy, and Scheinkman (1994)


Hog prices in the US
hog price
80
70
60
50
dollars
1925
1930
1935
1940
1945
1950
1955
1960
year

Ordinary models of supply and demand don't generate these cycles.

- find p and q from $q^d(p) = q^s(p)$



Hypotheses:

- Farmers need time to raise hogs (say, one "period")
- Farmers forecast future prices using past and current prices

Outcomes:

1. Suppose price is currently high
2. Farmers $\uparrow$ capacity, shift towards hog production
3. Next period, high supply floods the market, prices $\downarrow$
4. Seeing this low price, farmers $\downarrow$ capacity
5. Next period, supply is low and prices $\uparrow$ ...

In this scenario,

$$q^d(p_t) = q^s(p^e_{t-1})$$

- p^e_{t-1} is the **expected** time t price, formed at $t-1$

But how to farmers form expectations?

First guess:

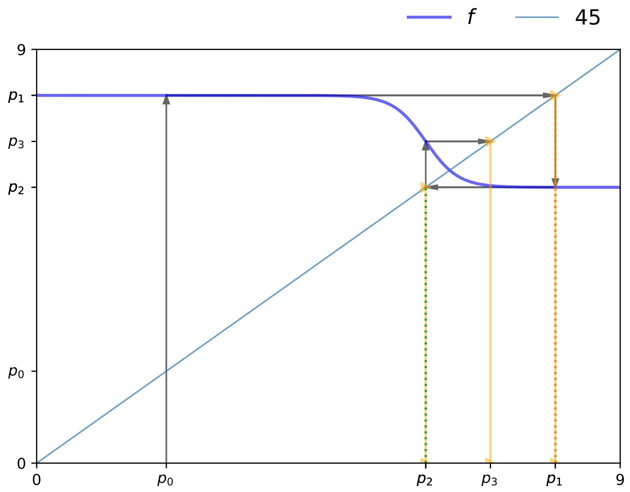
$$p^e_{t-1} = p_{t-1}$$

So now we have

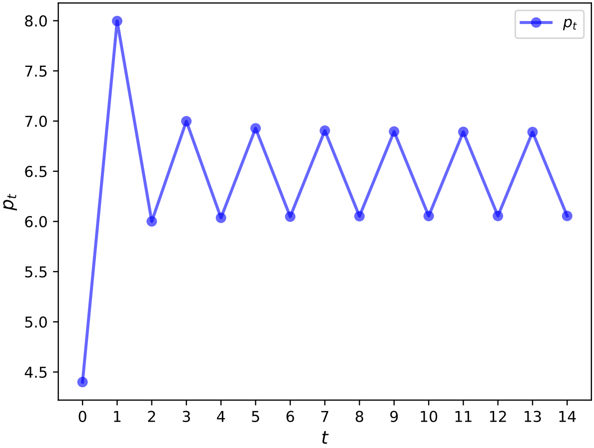
$$q^d(p_t) = q^s(p_{t-1})$$

Solving for p_t gives

$$p_t = f(p_{t-1}) \quad \text{where} \quad f(p) = (q^d)^{-1}(q^s(p))$$



f
45
9
p_1
p_3
p_2
p_0
0
0
p_0
p_2
p_3
p_1
9



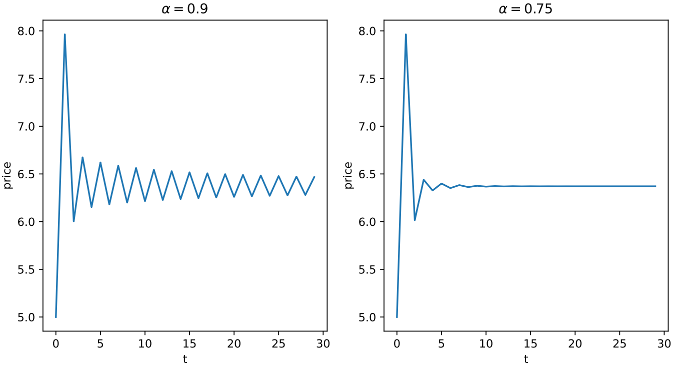
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
p_t
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
t
p_t

The model replicates cycles — but there are problems!

Predictions are **very sensitive** to how we model **expectations**

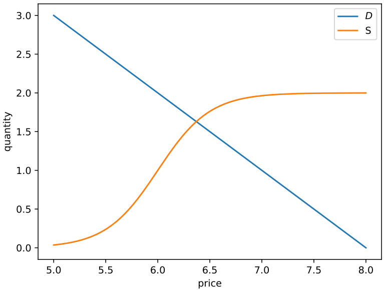
Example. Suppose we switch to $p^e_{t-1} = \alpha p_{t-1} + (1-\alpha) p^e_{t-2}$

- Called "adaptive expectations"



$\alpha = 0.9$
$\alpha = 0.75$
price
t
8.0
7.5
7.0
6.5
6.0
5.5
5.0
0
5
10
15
20
25
30

Or we could use "rational expectations"



Lessons:

- Model predictions are very sensitive to behavior, expectations
- Modeling human behavior is essential
- The “right” way to model humans is unclear

Summary: economic modeling is hard – but we shouldn’t give up!

Scientific computing in economics

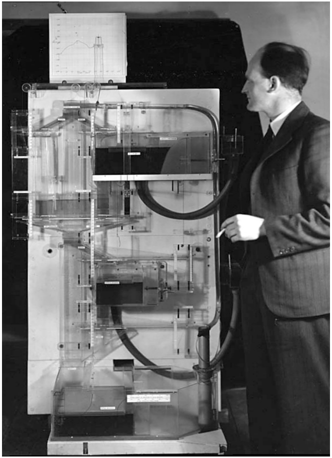
Economists are relative newcomers to the field of computational sciences...

Economists have long been influenced by dogmatic tribalism...

It would appear that many (so called) 'theories' have been poorly (if at all!) proven...

Computational models in economics are still often simplistic...

– Consultant's report on HPC in economics



Actually economists are pioneers (William Phillips, 1949)

Examples of computational work in economics and finance

- DSE - schelling - Pricing a European option

Trends in scientific computing

compare languages, talk about jit compilers, illustrate with google jax.

The limits of computer power

* Linear assignment * Brute force optimization

* The importance of algorithms * How algorithms interact with advances in hardware/software

What about machine learning and AI?

* Why machine learning is not enough – current inflation unprecedented – think about that word * Insufficient and nonstationary data – forecasting GDP * The need for careful mathematical modeling