

Collaborating with Leon – A Recollection

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Outline of Presentation

- How Leon and I got started and related remembrances
- An Intermediate Microeconomics view of the first inventory paper (AER March 1982)
- Extensions of the first paper
 - Dynamic monopoly production, inventory, and price policy under sophisticated demand (Economic Letters 1982)
 - A Model of the Firm in Time and Space (JEDC 1985)
- Final Thoughts

Blog Post

Monday, October 14, 2013

Leon

I got notified last night that Leon Moses passed away. There was information about a memorial service and an **academic biography**. He was almost 89 and his wife had passed away earlier this year. I suspect he led a full life, though we stopped corresponding after the 1980s, so I'm unaware of the specifics of what he did later.

My first published paper was with Leon and it got into the AER; so that was plum. And it was a good thing too since the papers I had carved out of my dissertation were going nowhere and I spent about three years pushing them before moving onto other research.

I was surprised to see that my adviser, John Ledyard, also had a piece with Leon. I had thought my collaboration with Leon a bit odd, but seeing the paper with Ledyard maybe it wasn't so unusual. Here's the story behind it.

Getting Started with Leon

- Grader for his C10 (Intermediate Micro) class
 - My third year (1978-79).
 - He was in transition from Transportation Center to Economics.
 - In retrospect, he may have been looking for a junior colleague more than for a grader, but that's just a guess.

Talking about Inventory

- Sometime in the middle of the quarter Leon and I had our first conversation on his ideas.
- The intuitions were all his.
- He needed help with modeling the dynamics.
- Earlier I had taken Kamien and Schwartz's class on dynamic optimization.

Impressions and Recollections

- I can hear Leon's voice and see Leon's face in my mind.
- It is harder to remember the substance of the conversations.
- But I recall that during them he would often go to the blackboard and draw a diagram to explain his thinking.

More on Impressions

- Leon was 11 years younger than my dad and 4 years younger than my mom. They were near contemporaries.
- My parents knew nothing about academic economics – so this was the closest thing for me to intergenerational learning in an academic way.
- The relationship was symbiotic –
 - I learned the importance of straightforward intuition.
 - He needed that confirmed and expressed in current technique.
- Sometimes we'd disagree, but in a very collegial way.

The First Inventory Paper

Inventory Investment and the Theory of the Firm

By LANNY ARVAN AND LEON N. MOSES*

The modern analytical approach to inventory behavior began with the collections edited by Kenneth Arrow, Samuel Karlin, and Herbert Scarf (1958, 1962); Arrow, Karlin, and Patrick Suppes; and the work of A. Dvoretzky, J. Kiefer, and J. Wolfowitz (1952a,b, 1953); George Hadley and Thomson Whitin; Charles Holt et al.; Edwin Mills; Franco Modigliani and Franz Hohn; Harvey Wagner and Whitin; and Whitin. These scholars were experts in the theory of the firm. Yet, in the inventory area, their work departed from the main constructs and tradi-

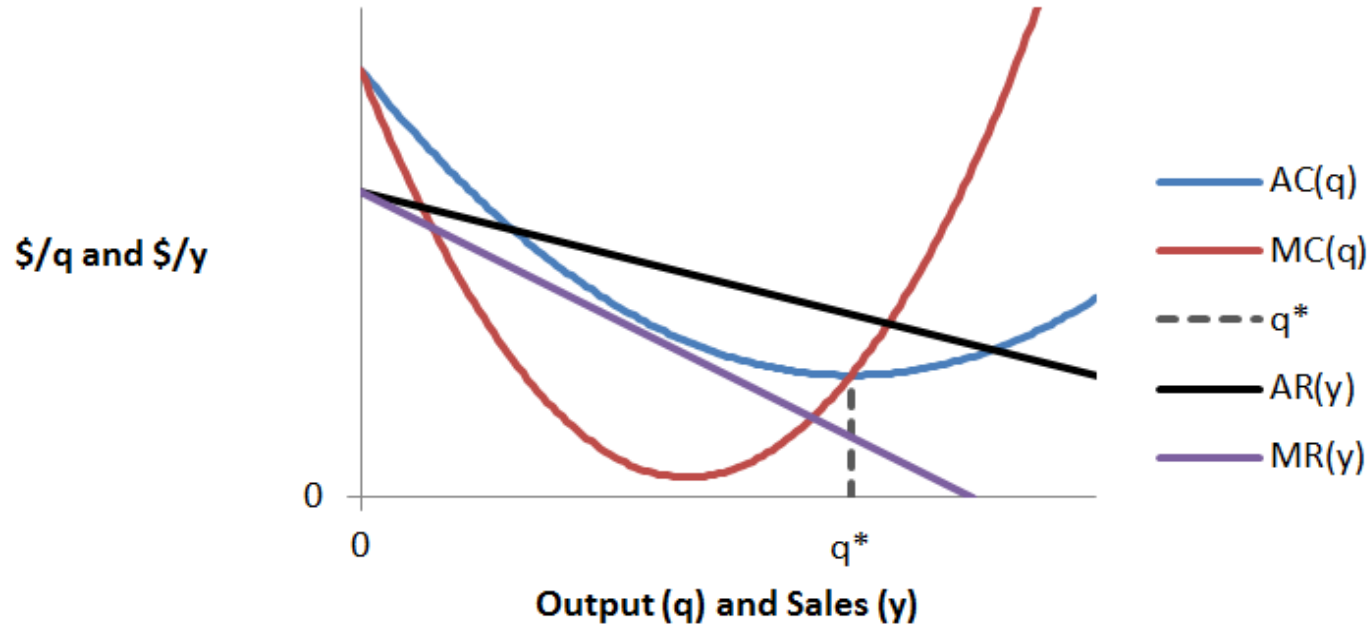
relief the difference between monopolistic and perfectly competitive firms. Given that the Wagner-Whitin paper was published in 1957, and the Mills volume in 1962, it is surprising to find that the number of inventory studies in which price is taken into account is still very small. It is worth noting that a recent, excellent and very comprehensive volume on inventory theory by R. Peterson and E. A. Silver devotes only two of its approximately eight hundred pages to a review of models in which firms make price decisions.

A Remark On the Fixed Price Assumption

- Leon didn't like that much of the literature ignored prices altogether or implicitly assumed prices were fixed.
- But in Dale Mortensen's class we had studied implicit contract theory, which gave a micro-foundation for sticky prices.
- The implicit contract story is dynamic, but the models at the time were static.
- Sticky and stuck are not the same. When do prices change?
- Leon and I ended up assuming complete price flexibility.

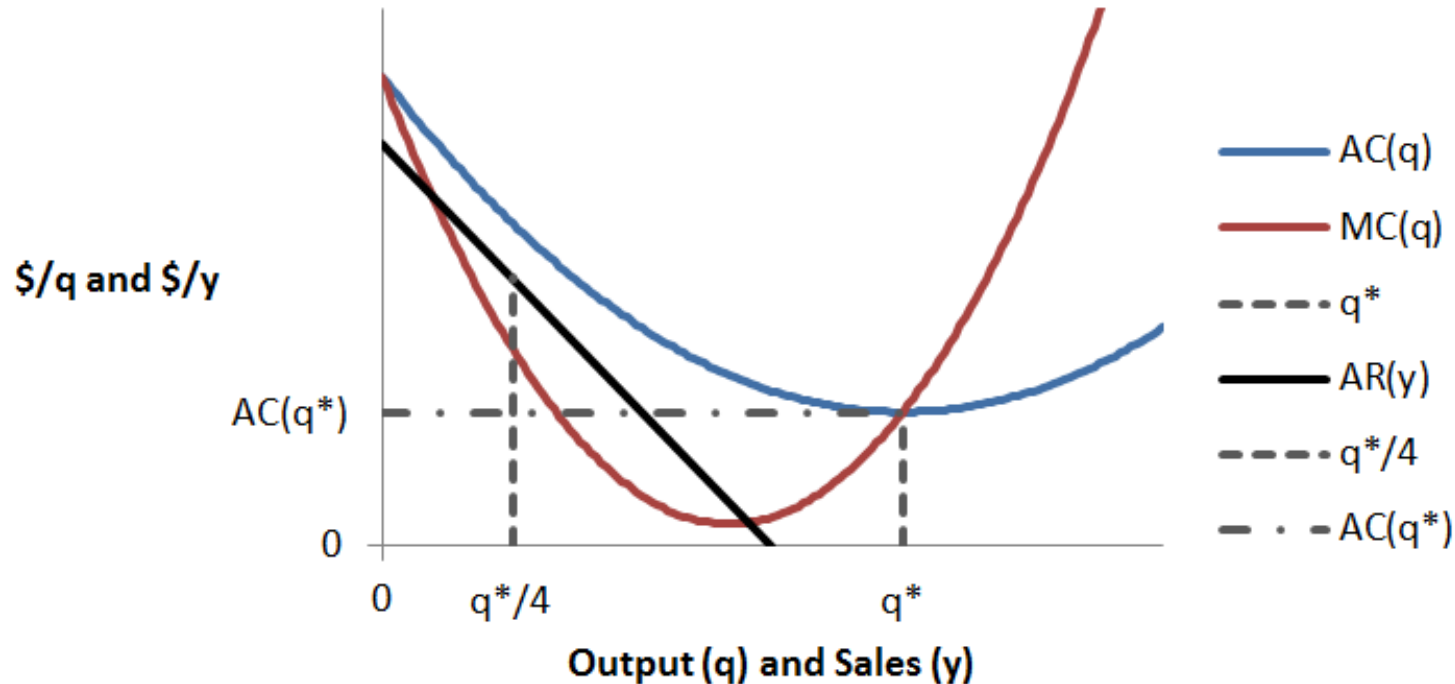
Downward Sloping Demand and U-Shaped Average Cost

Figure 1 from Paper



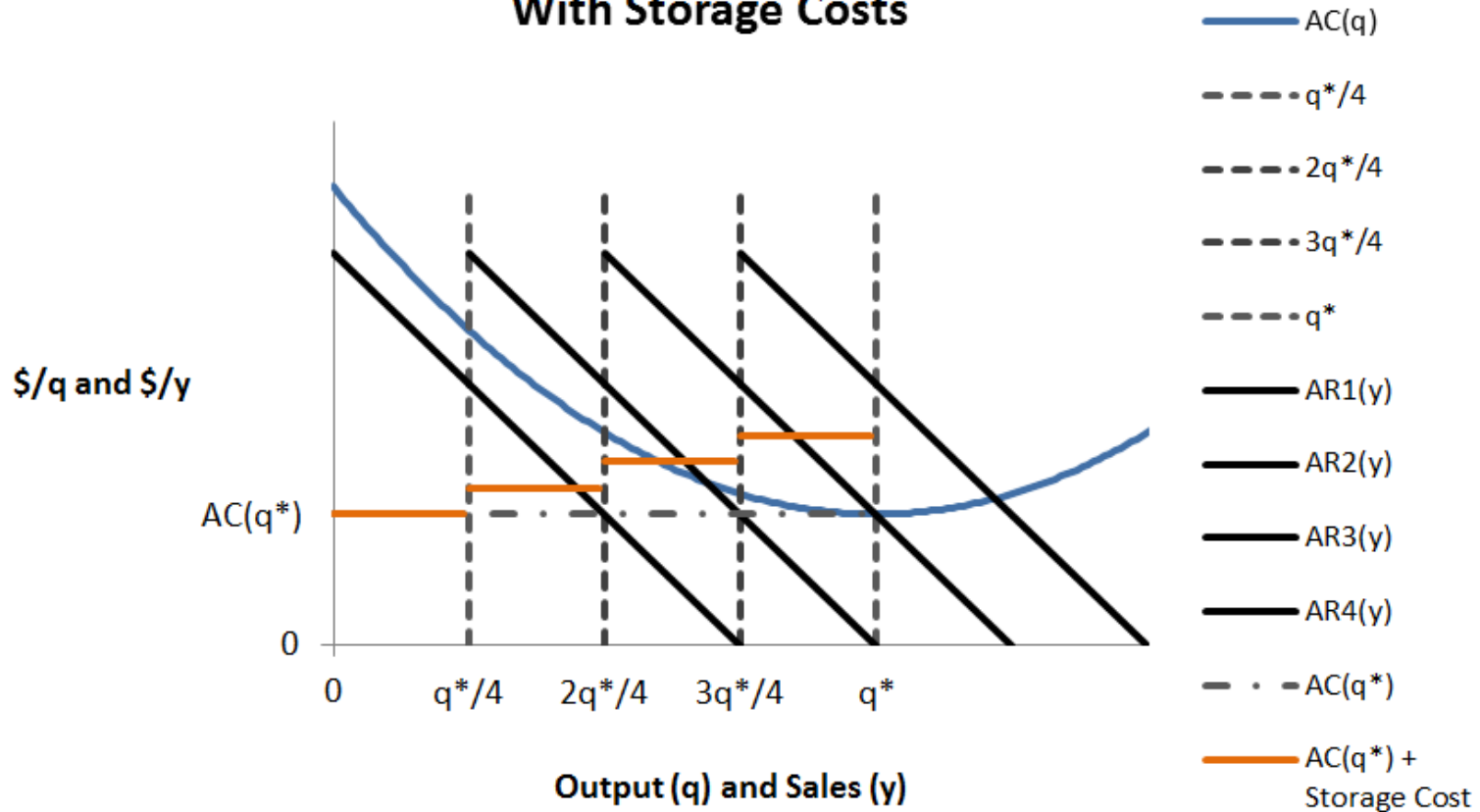
Demand Everywhere Below Average Cost

AR everywhere below AC but $AR(q^*/4) > AC(q^*)$



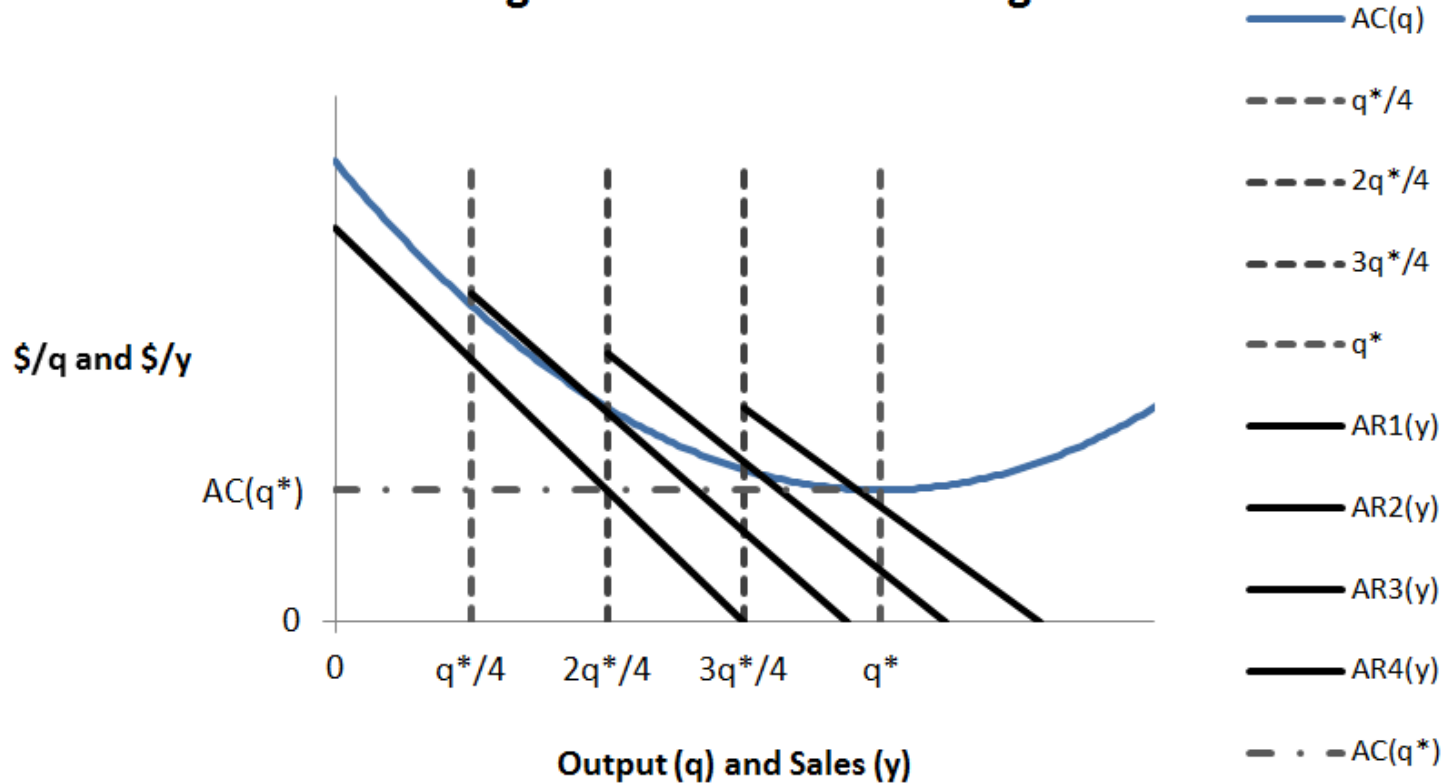
Production over 4 Periods

With Storage Costs



Buyer Pays Storage and Discounting

Storage Costs and Discounting



Back to Leon's Point

- There is no reason to assume time invariant demand.
- But even if you do, once there is batch production covering multiple periods, with storage costs and discounting, demand elasticity will vary from period to period.
- This suggests intertemporal price discrimination.
- We weren't the first to make this point.
- But recent papers on inventory were still assuming fixed price (or fixed output).

The Full Model Solves For

1. The optimal output – not necessarily q^*
2. The optimal number of periods over which that output is sold
3. The optimal price path
4. Together, 1 - 3 imply the optimal inventory path.

Technical Issue –

Discrete Time or Continuous Time?

- Discrete time approach can entail integer programming issues in calculating the optimal number of periods.
- But in continuous time, the economies of scale must be modeled correctly – in production of the stock of output, not the flow.
 - The batch is available when sales begin and the next batch is not available till the previous batch is exhausted.
 - u-shaped average cost in flow production is really constant returns up to q^* via alternating production rapidly between on and off.
 - There was a mistake in original paper. An Erratum was published.

Why Aren't Buyers More Sophisticated?

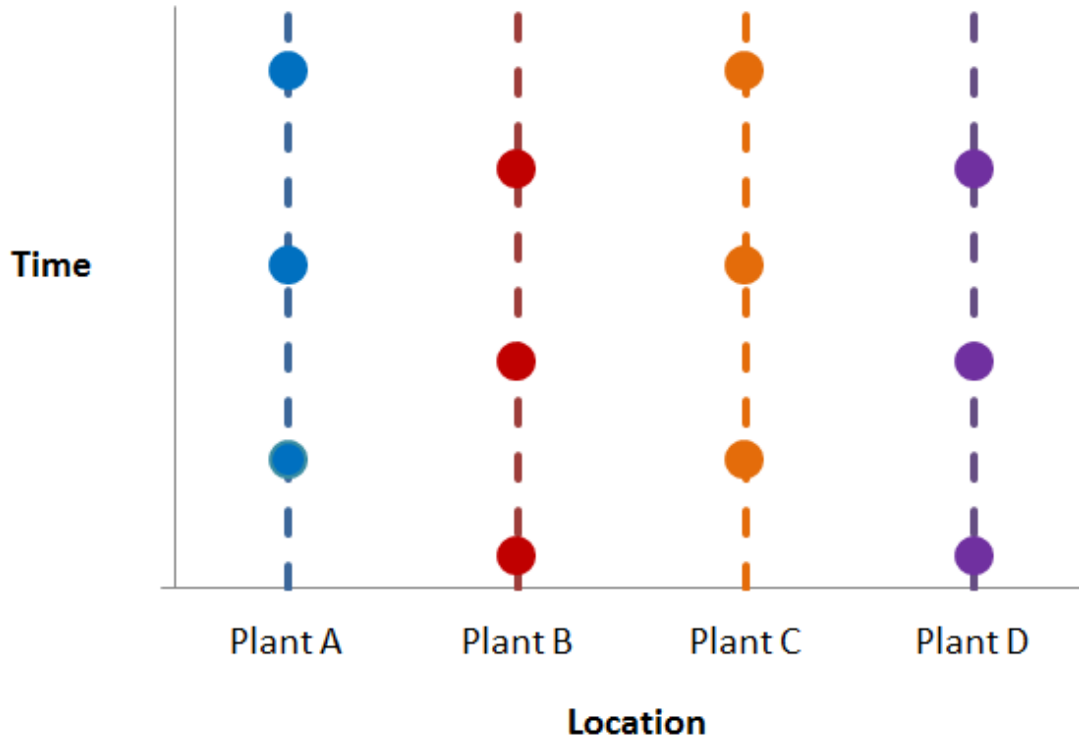
- If buyer's are aware that price will vary over time, won't they engage in some intertemporal substitution?
- Then shouldn't the demand at any time depend not just on the price at that time but at other times as well?
- The Economic Letters piece addresses this criticism. A representative consumer has an intertemporal budget constraint where money can be borrowed or saved.
 - There is a time consistent solution that gives similar results as in the naïve model.
 - But some parameter, e.g., the demand intercept, must be determined endogenously to assure time consistency.

Time and Space

- Multiple plants in addition to batch production at each plant.
- In principle this leads to the possibility of staggered production and cross hauling.
- This is potentially quite interesting but there are (again) integer programming issues in solving this sort of model.
- We solved a simpler model without staggered production and with no cross hauling.
 - Where does economics end and operations research begin?

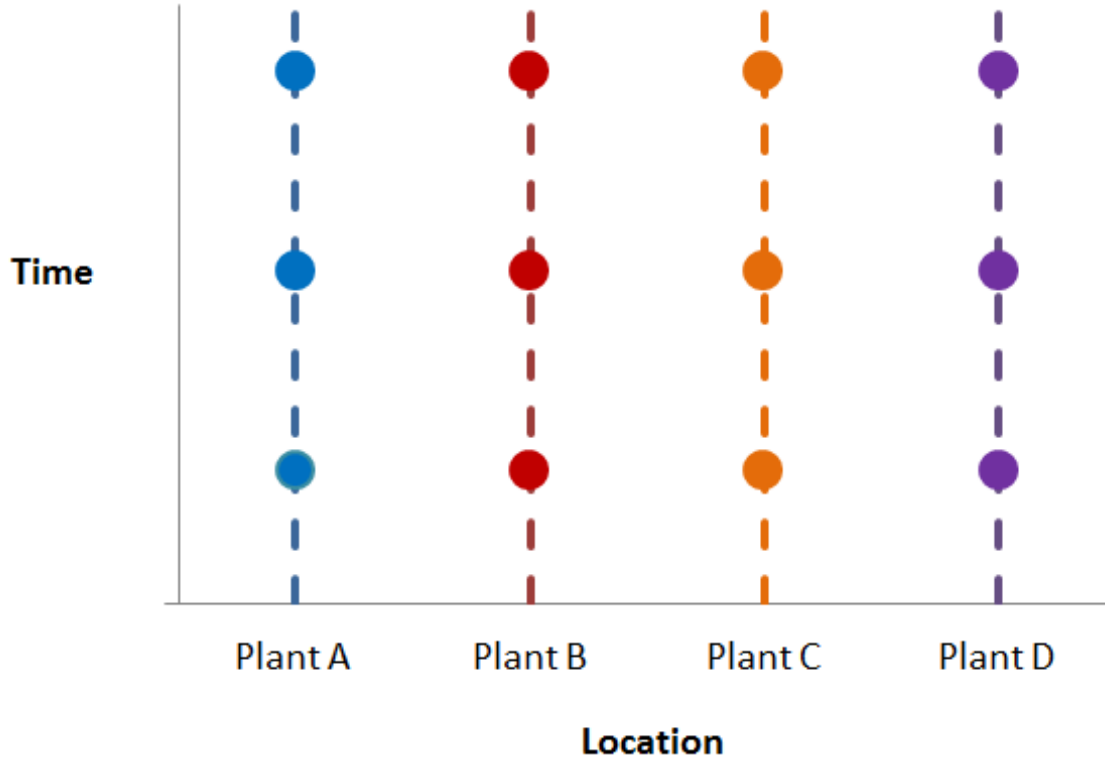
Simple Stagger In Production

Simple Stagger in Batch Times



The Model in the Paper

Uniform Batch Times



Time and Space 2

- We got to present an early version of this paper at a conference in Umeå, Sweden.
 - Leon was excellent in a social setting
 - Very collegial about offering opinions on the work of others.
- This marked the end of my collaboration with Leon. I can't recall whether I talked with him later or not.

Final Thoughts

- Let me conclude with how my interaction with Leon affected me thereafter.
 1. Paper on [duopoly with inventory](#).
 2. Became more intuitive (though not just because of Leon).
 3. Other reasons for becoming more intuitive:
 - a) Having kids,
 - b) Teaching intermediate micro,
 - c) Developing an interest in how people learn.
 4. But Leon was where I got my first real exposure.
 5. I am now a few years older than Leon was when he and I first met.