OTHER THINGS EQUAL

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The *A*-Prime/*C*-Prime Theorem

I am pleased to announce a theorem about theorems which describes tolerably well how half of economics has developed. It goes like this:

> **The *A*-Prime/*C*-Prime Theorem**
> For each and every set of assumptions A implying a conclusion C, there exists a set of alternative assumptions, A', arbitrarily close to A, such that A' implies an alternative conclusion, C', arbitrarily far from C.

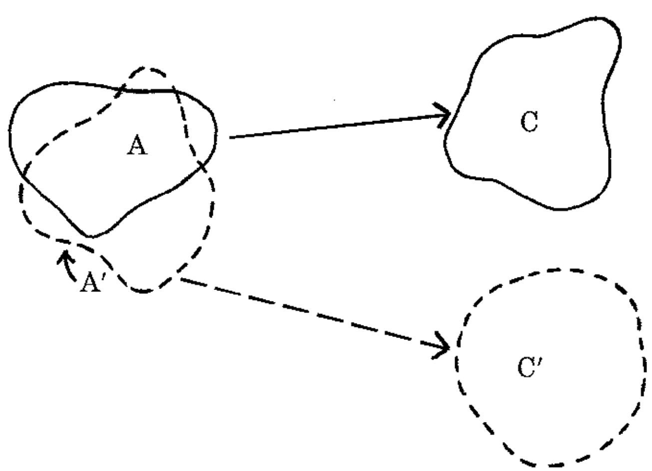
Take free trade as an example. Suppose that the first set of assumptions, A, are competition, convexity, full employment, and so forth, which lead to the blackboard conclusion, C, that "the North American Free Trade Agreement is swell for the American economy." Imagine a paper published at time t drawing such a conclusion (sorry: I just can't express myself without mathematics). You know as well as I do what will happen before time $t + 1$: a paper will be published showing that, on the contrary, if the assumptions are jiggered a bit, to A', by introducing, say, a nonconvexity in the ith industry, then the old conclusion falls, and C' is erected in its stead: "the North American Free Trade Agreement is rotten for the American economy." If you don't like nonconvexity (it covers a lot of ground), try transaction costs or macroeconomic considerations.

Look at the figure on the following page. It says that if you change the assumptions a little (the economic theorems in question don't provide a standard for how little) then the conclusions, if you're clever about it, can change as much as you want.

Ask yourself whether the *A*-Prime/*C*-Prime Theorem doesn't pretty well describe half the contents of economics journals nowadays. (It described them in olden days, too, right back to Plato, but that's another story.) The figure of a half comes from Wassily Leontief's observation that half the contents of the leading economics journals are theoretical, the same percentage as in sociology, and by contrast with the mere ten percent in the leading journals of chemistry and physics [Leontief, 1982].

Take, for example, rational expectations. Professor L of Chicago proves on a blackboard that certain assumptions A lead to the conclusion C that the public can figure out what the government is up to, and so the government can't fool all of the people all of the time. A implies C. Some months later Professor F of Harvard proves that if you alter the assumptions A by what looks like a tiny bit, making them

FIGURE
A Small Change in Assumptions Can Always Be Found That Leads to a Large Change in Conclusions



into A', the conclusion changes to C'. The efficacy of government policy, and the foolishness of the public, is gloriously reinstated. But the theorem can be applied as many times as the scholarly audience can stand it, and is. Professors X, Y, and Z now spring forward to prove other theorems about the formation of expectations and the efficacy of policy. Within a few years the air is thick with A, A'', A''' and their corresponding Cs.

Or take game theory applied to industrial organization, if you please, and read Franklin Fisher's devastating summary in a recent article in the *Rand Journal of Economics*. Notice that game theory has 130 solution concepts and counting, A^{130}; and notice that finite games unravel and that infinite games have infinite numbers of solutions, C^{∞}. Or take, if your tastes run that way, abstract general equilibrium. Or macroeconomic theory. Or econometric theory. Or the theory of international trade. Or the burden of the debt. Or the revivals of growth theory innocent of economic history. Or the many misreadings of the Coase Theorem (someday the people writing on Coase might want to read a little Coase). Or this or that rediscovery of monopolistic competition (someday they might want to read a little Chamberlain). The A-Prime/C-Prime theorem says that if these subjects stay on the blackboard, as they all do, then they are doomed to wander through A, A', A'', A''' without limit.

What's going on? Why do economists persist in believing, against their science, that intellectual free lunches are to be had daily on the blackboard? The answer is that economics has adopted the intellectual values of the math department instead of the physics department. (Again it's nothing new: it also goes back to Plato.)

In other words, economics, surprisingly, is more mathematical than physics. I'm not saying that economists know more math than physicists do, which is false. The average physicist is a stunningly better applied mathematician than the average economist. I'm saying what's true, that economists have adopted the intellectual values of the math department. By contrast, the physicists, unlike mathematicians and economists, are not in love with blackboard proof.

The contrast comes out in new Sante Fe Institute, founded recently by Kenneth Arrow and a famous physicist to help economics imitate physics. In 1989 *Science* described the physical scientists at the Institute as "flabbergasted to discover how mathematically rigorous theoretical economists are. Physics is generally considered to be the most mathematical of all the sciences, but modern economics has it beat" [Pool, 1989, 701]. The point is that the physicists do not feel "beaten", since unlike economists they do not regard mathematical rigor as something to be admired for itself. They have used the Schrödinger equation happily since 1926 without knowing whether it has solutions in general. They can't solve the three-body problem, but can simulate the path of the moon to any required degree of approximation.

Economists assure each other that science involves axiomatic proofs of theorems and then econometric tests of the implied correlations. But the economists are mistaken, as they would see if they were to look outside the math department for their model of science. "It is to be admitted," wrote the philosopher of science Paul Feyerabend, "that some sciences going through a period of stagnation now present their results in axiomatic form, or try to reduce them to correlation hypotheses. This does not remove the stagnation, but makes the sciences more similar to what philosophers of science think science is" [1978, 205].

In truth the physicists could care less about mathematical proofs and very little about correlation hypotheses. They simulate, they calculate, they spend their time reading the physical equivalent of agricultural economics or economic history. Pure pencil-and-paper guys are common enough in physics departments, but they do not set its intellectual agenda. Our own Buz Brock found to his surprise that

> it is important for the economics reader....to realize that many natural scientists are not impressed by mathematical arguments showing that 'anything can happen' in a system loosely disciplined by general axioms. Just showing the existence of logical possibilities is not enough for such skeptics. The parameters of the system needed to get the erratic behavior must conform to parameter values established by empirical studies or the behavior must actually be documented in nature. [1988, 2 (typescript)].

Actually documented in nature: that's what interests scientists. To the seminar question asked by an economist, "where are your proofs?" the physicist replies, "You can whip up theorems, but I leave that to the mathematicians" [Pool, 1989, 701].

When a problem came up in a seminar at the Sante Fe Institute, the best physicist present solved it overnight with a computer simulation, approximately, while the best economist, likewise overnight, derived an analytic solution, exactly. Who is the more mathematical?

Economists arguing over the federal budget next year or the stability of capitalism forever want to know *how big* a particular badness or offsetting goodness will be. Will the distribution of income be radically changed by the outlawing of interest? Will free trade with Mexico raise American national income much? Mathematics does not care about such questions of magnitude. Disproving the Goldbach Conjecture, which is empirically true for every calculated case, would take only one even number, N, that could not be expressed as the sum of two primes. Mathematics does not care if N were the only such number: the Conjecture would be falsified. Science cares. For engineering purposes, making a computer lock, for example, the Goldbach Observation works fine, whether proven as a theorem or not.

So economics needs to imitate physics and stop imitating mathematics. Notice: I did not say "stop *using* mathematics." It would be idiotic to complain of the *use* of mathematics. You might as well complain about using English or using diagrams. But the A-Prime/C-Prime Theorem proves that we are overinvesting in math-department questions of existence and underinvesting in physics-department questions of magnitude.

Well, not exactly "proves". It's an empirical question. Come to think of it, I haven't yet found a proof of the Theorem. But as the physicist said, "You can whip up theorems; I leave that to the mathematicians."

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