The 1985 Nobel Prize in Economics

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FRANCO MODIGLIANI OF THE MASSACHUSETTS INSTITUTE of Technology was awarded the seventeenth Nobel Prize in economics. This choice was widely applauded since Modigliani has been a versatile and deep contributor to modern economics for 40 years.

Two countries can take pride in his being honored: Italy, from which he fled as a young victim of Mussolini's racial persecutions and whose postwar policy problems he has attentively researched; and the United States, where he received his Ph.D. training (at the "University in Exile," the New School for Social Research) and where he has held many university chairs.

More than 40 years ago, when Modigliani was only 25, he wrote a seminal article setting Model-T Keynesianism on its modern evolutionary path and probing its microfoundations in rigid, nonmarket-clearing prices (*1, 2*). Although neither this paper nor his 1963 classic (*3*), which set the pattern for today's post-Keynesian eclecticism, were mentioned in the citation of the Swedish Royal Academy of Science, they form the basis for the Federal Reserve Board–MIT–Penn forecasting and policy model that has long been useful in framing Federal Reserve monetary policy. As an MIT colleague documented at a September 1985 conference at Martha's Vineyard attended by scholars from all over the world to honor Modigliani, the best state of the macroeconomic art in these days after "monetarism" and "the new classical economics" of the rational expectationists, calls for a paradigm that is a natural evolution from those 1944 and 1963 classics (*4*).

Franco Modigliani shares one characteristic with his older countryman, Enrico Fermi. Fermi, also a refugee from Mussolini's Italy, was a doubly great physicist. In addition to being a great theorist, Fermi had the rare quality of being a brilliant experimentalist. Modigliani is recognized as an outstanding economic theorist. At the same time he insists on measuring empirical behavior patterns econometrically, refusing others all the pleasures of quantitative testing of his own novel hypotheses. Before he had ever heard of Karl Popper, Modigliani was already practicing the advice that a scholar should be his own most stringent critic. It is good for science; it is good for self-protection; besides, it is good fun.

In a field known for its voluble talkers, Modigliani is one of the fastest—quick off the mark in the short sprints, but ahead of the pack also for the long jog. Stealing a line from Sydney Smith's conversation with Thomas Babington Macaulay, I used to utter the mock complaint, "Franco, when I am dead you will be sorry you never heard the sound of my voice." Actually, as we both know, this is quite untrue. Economists from all over the world, and not least young scholars from Italy, bring their problems to Franco Modigliani. He is slow to digest the issues because he insists on fundamental understanding at every stage of the examination, avoiding facile handling. (Once, referring to a world-famous scholar, Modigliani said to me, quite guilelessly, unselfconsciously, and truthfully, "He's *deep*—like me.") Although known to be a lover of argument, Modigliani is also known as one who never argues for victory, but rather for truth. That is why, at 67, he remains a Mecca for both young and established researchers.

The Life-Cycle Saving Model

Modigliani has many brain children to his credit. All of a scholar's children are equal, but in my view the jewel in the Modigliani crown is his life-cycle hypothesis of saving, developed in collaboration with Richard Brumberg, a scholar who died young (*5*). The Royal Academy of Sciences agreed and mentioned it first in their official citation announcing the award.

I believe it to be the best single explainer, across time and space, of saving and investing behaviors and their responsiveness to various policy programs. From its deceptive simplicity, novel and testable expectations emerge. Here is how it goes.

Most of us will live beyond our prime earning years. So we must save when in our prime to accumulate the assets on which we will live in retirement. In the purest life-cycle model, when the end comes we'll die broke.

Simple stuff? They give prizes, you will ask, for that? Yes, so simple as to be fundamental. And the insights gained are far from simple or obvious. Suppose population ceased to grow (as in Denmark or the Germanies). Suppose productivity improvements that raise real incomes virtually cease (as happened from 1973 to 1980 over much of the globe). A life-cycle system without growth involves zero net saving and investment: saving of the young is canceled by dissaving of the old. Modigliani gets us to focus on the right questions. Growing nations save much, stagnating nations save little—a different hypothesis from "rich people save much, poor people little."

Science says: Let them who can be clever. What counts is which clever theory fits and predicts the observable facts. On this score Modigliani wins hands down. Early Americans, though poor, saved much; we affluent moderns save little. The fast-growing Japanese and Germans save much; the French and Italians, allegedly so romantic and carefree, have high saving rates between those of Japan and the United States.

An inexact science like economics benefits enormously from theoretical models that are themselves only partially accurate. Ten physiologists could make their reputations disproving aspects of Claude Bernard's seminal theories. Fifty economists win fame by finding exceptions to Modigliani's life-cycle paradigm. Leading that pack is Franco Modigliani himself. (Not knowing when we will die, we leave bequests willy-nilly. Some classes do dance to the bourgeois drumbeat and plan for their posterity's economic needs.)

Indifference of Leveraging

Modigliani has contributed both to the macroeconomics of business cycles and inflation and to the microeconomics of relative prices and rational decision-making. The 1985 award explicitly cited

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a second line of his work, that dealing with "efficient-market" analysis and leading to the 1958 Modigliani-Miller theorem concerning the neutrality of corporate leveraging (*6*).

Some companies float bonds as well as stocks; some eschew debt and any such "leveraging." The conventional wisdom before 1958 was that, depending on the growth prospects and intrinsic variability of your industry and product line, your corporation should ideally borrow a certain optimal fraction of its total capital needs. The canny board of directors that achieves this golden leveraging ratio lifts, so to speak by its own bootstraps, the total market value of its owners' shares. The lazy or stupid management, which either stays zero leveraged or overleverages, loses prospective wealth and, in a cruel competitive world, may in the long run be forced out of office.

Merton Miller and Franco Modigliani argued otherwise. "Chicken legs and breasts can be separately packaged at the supermarket: the values of each such package must add up closely to the value of whole chickens. Otherwise consumers can do their own packaging." Similarly, Modigliani and Miller showed that firm A, with much debt and its entailed riskiness of common-stock earnings, cannot command a premium from risk-tolerant investors. Why not? Those investors can buy a zero-debt company on borrowed funds (margin purchases or collateral loans at the bank) and can produce with no premium that same attractive pattern of leveraged high-mean-return-cum-high-volatility. Similarly, no firm can win a premium by having a clean debt-free balance sheet. Private investors can put half their assets in leveraged stocks while keeping the other half in safe overnight deposits: that way they duplicate for themselves (premium free) whatever the clean balance sheet can produce. Conclusion: to a first approximation, total value to the owners of a company is invariant, independent of the degree of leverage, because investors can do for themselves, or undo for themselves, whatever leveraging can accomplish.

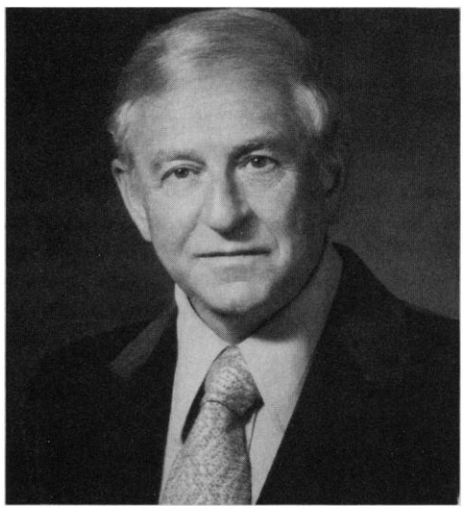
More important than deductive syllogizing is empirical testing, which showed that the alleged advantages of optimal leveraging could not be factually identified. Also important are deviations from the theory's axioms, such as recognition of how bankruptcy events can alter the simplicity and sweep of the proposition. Gratifying are corollaries, such as the 1961 Miller-Modigliani theorem that the percentage payment of earnings as dividends will not affect a stock's valuation.

We live in an age of accelerated corporate borrowing. This explosion in leveraging is in accord with the Modigliani-Miller theory: taxes aside, leveraging is neutral; inasmuch as deductability of debt interest from corporate taxation is patently favorable to borrowing, the 1960–1986 trend toward debt confirms the Modigliani-Miller analysis. We are left, though, with the puzzle: why do firms pay dividends to taxpaying shareholders? Why not buy back shares more than corporations actually do?

Self-Falsifying Prophecy?

Although a critic of the new Lucas-Sargent school of rational expectationism, Modigliani is himself a founder of rational expectationism (*7*). In a 1954 tour de force, written with Emile Grunberg, he contributed a solution to the old problem of whether correct prediction is a self-contradictory impossibility (*8*).

Here is how the late Oskar Morgenstern put the issue in a 1928 publication that led ultimately to his collaboration with John von Neumann on *The Theory of Games and Economic Behavior* (*9*). The diabolical Professor Moriarty pursues the incomparable Sherlock Holmes. Holmes boards in London the Dover train that makes an intermediate stop at Canterbury. Moriarty can just catch his prey in Dover if he flies a geodesic to there; however, if the quarry



Franco Modigliani

anticipates that fate and gets off in Canterbury, the gambit will fail and Moriarty will rue that he did not aim for Canterbury and victory there. We seem to be in the regression, What does A think B thinks A is thinking . . . ?, and so forth, seemingly endlessly. Morgenstern concluded that perfect prediction is impossible, since knowing it must alter it.

Now the white knights Grunberg and Modigliani come to the rescue of the logical possibility of perfect prediction. Here is how they would treat the case of a never-published Gallup poll that can correctly predict the fraction of votes, x, that Ike will get while Adlai gets $1 - x$. Provided no one is apprised of this datum, the election will (by hypothesis) yield an actual outcome fraction that equals the predicted fraction: $x' = x$. No Morgenstern problem yet. Suppose now that the Gallup fact of x is announced to the electorate. Then there may be a bandwagon effect: when $x > 1/2$ is announced, impressionable voters shift over to the front runner Ike and the result is actual $x' >$ predicted x. In this case, no correct prediction by candor is possible. Or, suppose there is an "underdog" effect, which is the reverse of a bandwagon effect: now when x is announced greater than 1/2, some voters pity Adlai and the shift of their votes makes actual $x' <$ predicted x. Again, candor destroys omniscience.

Grunberg-Modigliani (*8*) cut the Holmes-Moriarty knot thus. Stipulate that there is a knowable law (never mind *how* it is knowable), which specifies what actual x' will be for each pair of poll-finding x and *reported*-finding y:

$$x' = \text{known continuous function of } (y; x)$$
$$= f(y; x);\ 0 \leqq [x, y, f(y; x)] \leqq 1$$

Then they conclude, "Whatever the x finding that occurs, there is always a calculable y report that will be a self-fulfilling prophecy with actual x' = published-prediction y."

The proof is trivial, a one-dimensional application of L. E. J. Brouwer's 1912 fixed-point theorem. (Doubters can try to move from a square's left wall to its right wall, never taking pencil off paper, and avoiding ever touching the square's diagonal.)

As the authors stress, the continuity assumption is basic to the demonstration. Thus, suppose that the variables (x, y, x') must be rational numbers (as literally they must be if the electorate is finite in number). The above square then is replaced by a lattice of nails lined up in the same number of rows and columns.

Can we tie a long red string around a specified nail in each column, and end up with a path for the string made up of line segments—a path that traverses from the first left-hand column to

the last right column, without ever touching any nail in the diagonal of the lattice? Of course we can; and in a stupendous number of ways. Indeed if we knot our string around each column's nail selected at random, the odds are better than one-third that the resulting x will never equal the reported y [the exact probability being almost exactly $e^{-1} = (2.73\ldots)^{-1}$]. The 1928 Morgenstern point thus can still be a worry.

All this relates to rational expectationism, à la John Muth and others, as follows. A rational-expectation equilibrium time-profile of economic variables must be such that, if everyone were apprised of it, they would together all recreate exactly that profile. Hail to the Carnegie-Mellon workshops of the 1950's where Herbert Simon, John Nash, Abraham Charnes, William Cooper, John Muth, Charles Holt, Albert Ando, and Franco Modigliani made intellectual history with the perceptive support of Dean George Leland Bach.

Ad Hominem Matters

Hitler and Mussolini enriched American science. Along with Einstein, Weyl, Bethe, Ernst Mayr, von Neumann and so many others in the natural sciences, they presented us with such economists as Joseph Schumpeter, Wassily Leontief, Jacob Marschak, Gottfried Haberler, and Abraham Wald. Modigliani, by his youth, was at the end of this illustrious migration. By good luck, Jacob Marschak and Hans Neisser at the New School enabled him to land on his feet running. Great universities—Chicago, Illinois, Carnegie-Mellon, Northwestern, MIT—recognized his merits and he repaid their perspicuity. Every scholarly honor came his way, and fittingly early—presidencies of the American Economic Association, the Econometric Society, the American Finance Society, and so forth. Not only have governments benefited from his wisdom, but in addition he has helped universities and academies recognize undervaluations in Wall Street.

Still, there is one remarkable feature in Modigliani's scholarly profile. No lone scholar he; instead, dozens of his most famous contributions have been with joint authors, bearing such bylines as Modigliani-Ando, Modigliani-Brumberg, Modigliani-Grunberg, Modigliani-Miller, Modigliani-Samuelson, Modigliani-Drèze, and Modigliani-Papedemos. No one doubts Franco Modigliani's autonomous originality; all envy his ability to raise his own productivity and that of others by intense and joyful collaboration.

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Research Articles

Structure of Tobacco Mosaic Virus at 3.6 Å Resolution: Implications for Assembly

KEIICHI NAMBA AND GERALD STUBBS

X-ray fiber diffraction analysis of tobacco mosaic virus (TMV) has led to the building of a molecular model of the intact virus, based on a map at 3.6 Å resolution derived from five separated Bessel orders. This has been made possible by advances in the solution of the fiber diffraction phase problem. It is now possible to understand much of the chemical basis of TMV assembly, particularly in terms of intersubunit electrostatic interactions and RNA binding. Consideration of the molecular structure in conjunction with physical chemical studies by several groups of investigators suggests that the nucleating aggregate for initiation of TMV assembly is a short (about two turns) helix of protein subunits, probably inhibited from further polymerization in the absence of RNA by the disordering of a peptide loop near the inner surface of the virus.

TOBACCO MOSAIC VIRUS (TMV) HAS BEEN A MODEL SYSTEM for the study of protein–nucleic acid interactions and macromolecular assembly since Fraenkel-Conrat and Williams (*1*) showed that infective virus could be reconstituted from dissociated RNA and protein. Structural studies of the intact virus were begun by Bernal and Fankuchen (*2*), using x-ray fiber diffraction from oriented gels (*3*). These studies led to the calculation of a partially interpretable map at a nominal resolution of 4 Å (*4*). The virus is rod-shaped, 3000 Å long and 180 Å in diameter, with a central hole of diameter 40 Å. Approximately 2,130 identical protein subunits of molecular weight 17,500 form a helix of pitch 23 Å with 16⅓ subunits in every turn, protecting a single strand of RNA that follows the basic helix between the protein subunits at a radius of 40 Å. There are three nucleotides bound to each protein subunit.

Assembly of TMV is initiated by the binding of RNA to a

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