Models for Real-World Markets
Unanticipated Structural Change and Rationality in Macroeconomics and Finance

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Roman Frydman and Michael Goldberg (2007), *Imperfect Knowledge Economics: Exchange Rates and Risk*, Princeton University Press.

——————————(2011), *Beyond Mechanical Markets: Asset Price Swings, Risk, and the Role of the State*, Princeton University Press.

——————————(2014a), "The Contingent Expectations Hypothesis: Conditional Rationality in Macroeconomics and Finance Theory," May.

——————————(2014b), "Stock Prices in Real-World Markets: Evidence for the Present-Value Model," December.

——————————(2015a), "Rethinking Informational Efficiency in Real-World Markets: The Contingent Market Hypothesis," in preparation.

——————————(2015b), "A Rational Account of Swings in Asset Prices: The Role of Fundamentals and Psychology," in preparation.

Roman Frydman and Edmund Phelps (2013), "Which Way Forward for Macroeconomics and Policy Analysis?," in Roman Frydman and Edmund S. Phelps (eds.), *Rethinking Expectations: The Way Forward for Macroeconomics*, Princeton University Press.

A popular line of criticism of existing macroeconomics and finance models is that they are too abstract to be relevant.

However, as Eugene Fama has *rightly* argued, *any* macroeconomics and finance model is *necessarily a bold* abstraction:

> *"[T]o conclude that the model has no value...on the basis of the model's unrealistic assumptions is to forget what modeling is all about. The first purpose of a model is to improve understanding of some real-world phenomenon. [To this end, we must] abstract from unimportant...details, [and]...impose some simple structure on the world" (Fama, 1976, p.168).*

But, what are the "details" that are unimportant for understanding how outcomes unfold in real-world markets?

Eugene Fama, Robert Lucas, Robert Merton and those who adopted their approach to finance and macroeconomics have embraced a striking answer:

- *unanticipated* change in the economy's structure is unimportant for understanding the process driving outcomes.

Michael Goldberg and I have called the models that ignore such change *determinate*.

> *"[These models] structure the world in terms of a "market" that assesses probability distributions on future prices" (Fama, 1976, p.168).*

Remarkably, Paul Samuelson (1965) and Fama acknowledged that representing a "market" with a probability distribution

- is an "approximation...,which can be taken as true, at least until a better approximation comes along." (Fama, 1976, p.142)

In the first part of this talk, I focus on determinate models

- that rely on the rational expectations hypothesis (REH) to represent how a rational individual understands and forecasts outcomes.

REH underpins the New Keynesian approach, which aims to account for macroeconomic outcomes with models that

- exclude unanticipated change in the economy's structure (for example, DSGE models).

REH provides the theoretical foundation for the products created by "financial engineering."

- These derivative products largely ignore significant risks arising from structural changes that cannot be foreseen with probabilistic rules.

Michael and I have argued that REH models' widely reported shortcomings

- do *not* stem from their lack of realism *per se.*

Instead, REH models' fundamental flaw is

- that they are *abstractions* of a *hypothetical* "market," in which all structural changes can be fully foreseen.

The Present-Value Model for Stock Prices

$$P_t = \sum_{k=1}^{\infty} \left(\frac{1}{1+r}\right)^k \mathscr{F}_t^{\mathrm{M}}(D_{t+k}|X_t) \quad \text{for all } t$$

where, P_t and r denote the stock price and a discount rate, respectively; $\mathscr{F}_t^{\mathrm{M}}(D_{t+k}|X_t)$ denotes the the market's – an aggregate of its participants' – time-t forecast of dividends at $t+k$, and X_t represents information used by market participants to form these forecasts.

The usefulness of financial markets in guiding society's allocation of capital

- depends on whether asset prices reflect their fundamental values.

$$P_t^{\mathrm{F}} = \sum_{k=1}^{\infty} \left(\frac{1}{1+r}\right)^k D_{t+k}$$

The Efficient Market Hypothesis (EMH)

> *The prices of securities...are based on "correct" evaluation of all [available] information. (Fama, 1976, p.133).*

But how does the market arrive at the "correct" evaluation of information's impact on securities' fundamental value?

REH hypothesizes that

- An economist's *determinate* specification of dividends provides the basis for this "correct" evaluation.

EMH's startling claim then follows on *purely logical grounds*:

- except for a mean zero error term, the market prices assets exactly at their fundamental value.

The Nonessential Role of EMH's Nearly Perfect "Market"

Friedrich Hayek (1945, pp. 519-520): markets play an essential role in allocating society's resources,

- because central planning could not utilize "knowledge which is not given to anyone in its totality."

In REH models' "market",

- diversity of participants' understanding of the economy plays *no* role in setting asset prices.
- there is *only* one rational way to understand and forecast dividends and prices.

EMH provides no reason to favor financial markets over an economist, or a central planner, in guiding the allocation of capital.

Why Has EMH Failed?

The REH present-value model implies that an asset's fundamental value fluctuates around the market price.

In his groundbreaking paper, Robert Shiller (1981) pointed out that

- US stock-market indexes undergo long swings around *ex post* measures of stocks' fundamental value.
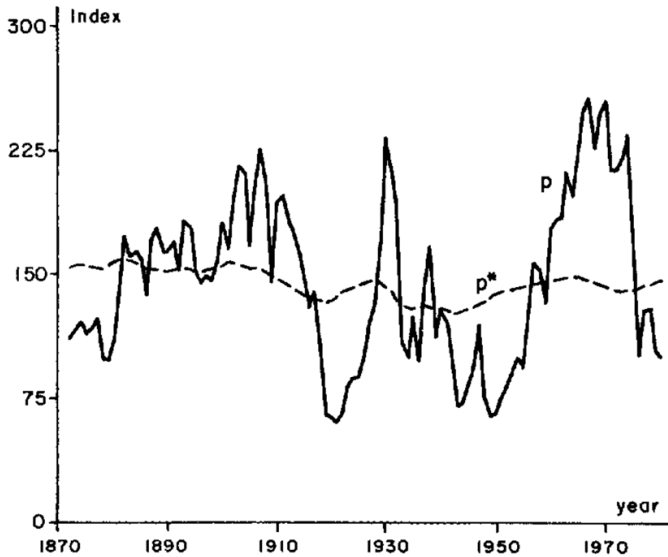
Shiller and others interpreted EMH's failure as evidence that

- "irrational" individuals drive stock-prices away from fundamental values,

Thus, long price swings are driven by psychological or technical factors that are largely *unrelated* to fundamental considerations.

Michael and I have pointed out that EMH has failed,

- because the REH present-value model represents stock prices in a "market" in which all change can be fully foreseen with a probabilistic rule.

But, in real-world stock markets

- REH represents forecasting by participants who forego profit-opportunities endlessly (Frydman and Goldberg, 2014b).

Imperfect Knowledge Economics (IKE)

Michael and I have proposed IKE models as *abstractions* of decision-making in real-world markets.

IKE opens macroeconomics and finance models to unanticipated structural change.

- Doing so, renders these models compatible with the diversity of ways in which *rational* participants understand and forecast outcomes.

Jettisoning determinate models raises a fundamental theoretical question:

How can models be open to unanticipated structural change and yet still generate predictions for time-series data?

Partly Open Models

IKE addresses this question

- by imposing qualitative and contingent constraints on *unanticipated* change in the model's structure, *ex ante*, at $t = 0$.

IKE models imply that co-movements in time-series data exhibit *qualitative* and *contingent* regularities.

In order to generate these implications, an IKE model is *only partly* open to unanticipated change.

To this end, the model hypothesizes *ex ante*

- that there are intervals of time during which such change is moderate,
- and that no one can fully foresee when such intervals might begin or end.

The Contingent Expectations Hypothesis (CEH)

CEH bases its representations of rational forecasting on regularities implied by an IKE model.

By relying on partly open models,

- CEH enables economists to incorporate *both* fundamental and psychological considerations into mathematical representations of *rational* forecasting.

The widespread belief that rational decision-making relies solely on fundamentals, whereas irrational decisions are largely rooted in psychology, is thus shown to be an *artifact* of determinate models.

The CEH Present-Value Model

$$P_t = \sum_{k=1}^{\infty} \left(\frac{1}{1+r} \right)^k \mathscr{F}_t^{\mathrm{M}} (D_{t+k}|X_t) \quad \text{for all } t$$

An economist's understanding of the dividend process recognizes structural change:

$$D_{t+1} - D_t = \Delta D_{t+1} = \Delta b_{t+1} X_{t+1} + b_t \Delta X_{t+1}$$

where, for example, $sign(b_t) > 0$, and X, denotes one informational variable, say company earnings.

The relationship between dividends and earnings is defined to undergo a moderate structural change if

$$|\Delta b_{t+1} X_{t+1}| < |b_t \Delta X_{t+1}| \text{ and } sign(b_{t+1}) = sign(b_t)$$

Whenever structural change between two adjacent periods is moderate:

$$sign(\Delta D_{t+1} \Delta X_{t+1}) > 0$$

CEH represents rational forecasting by imposing coherence

- between an economist's understanding of such qualitative regularities and that of a market participant.
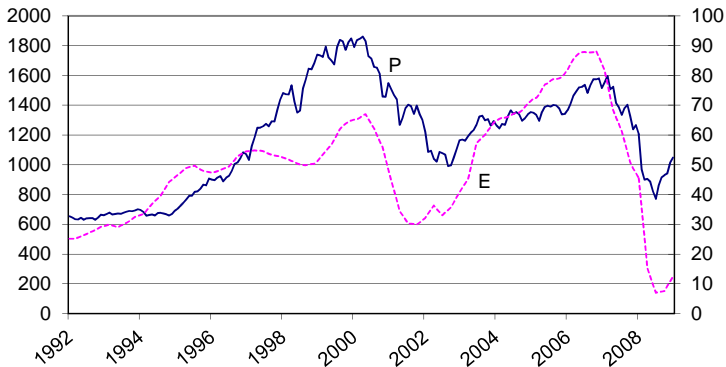
Such coherence implies that

- revisions of the market's forecast of dividends, and thus stock prices, co-move positively with earnings:

$$sign(\Delta P_{t+1} \Delta X_{t+1}) > 0$$

for all t during the intervals of moderate change.

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Figure 1
S&P 500 Stock Price and Earnings
1992-2009

CEH's Rational Account of Asset-Price Swings

The CEH present-value model can account for Shiller's (1981) and others' findings

- that stock prices undergo persistent swings away from and back toward benchmark values.

Frydman and Goldberg (2014b) show that such swings will occur during intervals in which

- change in the process underpinning stocks' fundamental values tends to be moderate,
- and the market forecasts that this change will continue to be moderate.

The CEH model accounts for psychological factors in *rational* forecasting.

However, contrary to the "bubble view," the model implies

- that fundamentals drive swings
- and once reverse direction, psychology *cannot sustain* the continuation of the price swing.

Econometrics of Partly Open Models (EPOM)

Our strategy for developing EPOM involves two steps.

First, we approximate a partly open process underpinning time-series data with a piece-wise linear specification.

To formulate such an approximation requires tests for structural change that do not prespecify when and how this process might change (Castle, Doornik, and Hendry (2012); Kitov and Tabor, 2015).

Determinate models' empirical difficulties imply that such procedures should become an integral part of how financial institutions and central banks "stress test" their models and risk-management systems.

EPOM's second step involves the development of estimation and testing procedures under the hypothesis

- *that the time-series data are generated by a partly open model.*

Søren Johansen, Anders Rahbek, and Morten Nyboe Tabor of University of Copenhagen have been working with us to build on the cointegrated VAR and bootstrap methodology to develop such testing procedures.

CEH Models' Policy Implications

REH models' irrationality in real-world markets calls for basing policy analysis on CEH models.

- This would require the fundamental rethinking of Lucas's (1976) REH-based approach to analyzing consequences of alternative policies.

CEH models account for Claudio Borio's and others' findings concerning the drivers of asset-price swings.

Thus, these models provide a conceptual foundation for macro-prudential policies for financial markets and the banking system.

More broadly, CEH models imply that, although asset markets play an essential role helping society take advantage of dispersed knowledge "which is not given to anyone in its totality"

- they necessarily can provide *only an imperfect assessment* of assets' fundamental values.

Replacing determinate models with partly open models that can account for unanticipated change in capitalist economies would help to restore much-needed balance to the public debate concerning what should be left to the market and what only the state and collective action can accomplish.