The Rowe Conjecture and the Efficient Market Hypothesis

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1 INTRODUCTION

In Chapter 2 of the recent biography of Keynes by Skidelsky the author goes over the current state of economics reviewing the various schools and the various underlying premises. The three premises are:

1. the rational expectations hypothesis (REH),

2. the real business cycle theory (RBC) and

3. the efficient financial markets theory (EFMT).

The REH assumes everyone has perfect knowledge. The RBC theory he explains rests upon the strong version of the REH which is markets always clear, a statement I have used from time to time, to my dismay, since they don't, and they don't in real time.

The EFMT, or as it is named here the Efficient Market Hypothesis (EMH), is the final leg of the three legged stool and it states that prices of all financial instruments or securities reflect all the risks that may affect them at any time. Well we have seen that this is not the case. He mentions one of the classic issues, herd mentality, and refers to a second, the stickiness of markets.

Yet as has been seen in the recent bubble, and in most likely all previous bubbles, people perceptions, reflected in some way in the herd mentality, can and does distort what the "true" facts are. The books by MacKenzie and Cassidy reflect some of these observations. The old classic works on business cycles also in some way portray these factors.

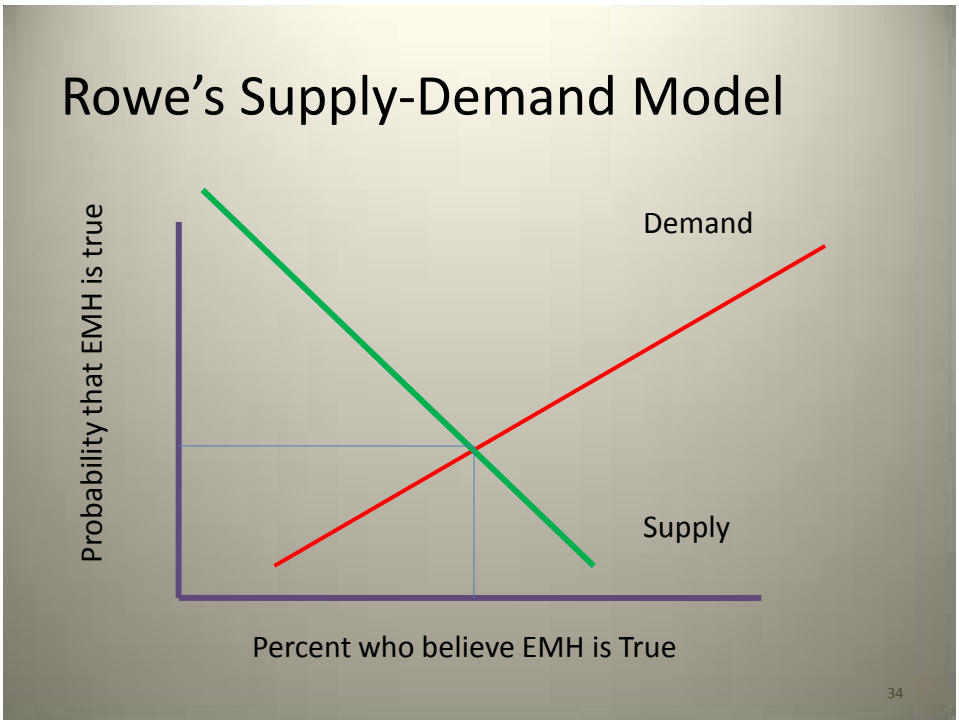
What Rowe has neatly presented is the nexus between perception and reality. This is the contrast in the statement "What are you to believe, my word or your lying eyes." People often believe what the herd believes despite the facts to the contrary. Bubbles are evidence of those facts.

In this brief note we summarize Rowe's description and then add another dimension. This is in no way a definitive result, it merely suggests an alternative view. Yet Rowe has clearly struck a resonant chord of some significant worth. Its continued pursuit is a worthy goal.

2 ROWE'S CONJECTURE

Nick Rowe of Toronto presented a conjecture concerning two variables as relates to the efficient market hypothesis, EMH. We briefly summarize his conjectures. He presents a

supply-demand analysis for the construct of the efficient market hypothesis with the axes being that of it being true and that of the buyers believing it is true.



We now quote from Rowe:

The downward-sloping (hence "demand") curve shows the extent to which EMH is true as a function of the extent to which people believe *EMH is true. At one extreme, if nobody believes that EMH is true, so people believe there is no relation between market prices and fundamental values, then each individual has a strong incentive to research carefully the fundamental values of assets before buying and selling, and so market prices will reflect all the information available to everyone, so EMH will be true.*

At the other extreme, if everyone believes EMH is true, so that market prices already reflect all available information on fundamental values, then no individual has any incentive to collect and process that information, and everybody picks assets by throwing darts, or buys the index, so market prices will not reflect any available information on fundamentals, so EMH will be false.

The upward-sloping (hence "supply") curve shows the extent to which people will believe that EMH is true as a function of the extent to which it is actually true. If EMH is totally false, people will (eventually) learn that it is false, and that it is sensible to collect and process information on fundamental values. If EMH is true, people will learn that too, and won't bother to collect and process information.

There will probably be lags in both curves. There will be a lag in the supply response if learning the extent of market efficiency takes time and experience. There will be a lag in the demand response if it takes time for market prices to drift away from fundamental values when people stop collecting information and start throwing darts instead. Maybe you can get a cobweb model out of these lags. Maybe that cobweb model would look like Minsky-esque cycles: markets start out efficient, so people slowly learn they are efficient, so they slowly drift away from efficiency...etc.

Don't take the picture too seriously. It's only a heuristic device. I don't know precisely what should be on the axes. The "extent to which EMH is true" could be perhaps be defined as the R^2 of market prices on fundamental values. But then different people have different bits of local information, and different costs of collecting and processing information, so it's not too clear exactly how much information should be reflected in fundamental values for 100% EMH. The "extent to which people believe EMH is true" could be defined as x% of the population believes that EMH is 100% true, or 100% of the population believes that EMH is x% true, or some combination. And what's important is whether they act as if *they believe it is true, of course.*

Since I don't know precisely what's on the axes, I can't say whether the demand and supply curves should be curved or straight, or whether they should hit the corners.
If a change in the market structure (allowing short sales?) made the market a more efficient processor of information, that would be represented by an upward/rightward shift of the demand curve. Note that a shift in the demand curve would be partly offset by a movement along the curve. A decrease in the costs of collecting information would be represented by a leftward/upward shift in the supply curve (more people collect information, thereby acting as if *they believed EMH were false. Again, the shift in the curve is partly offset by a movement along the curve.*

I haven't seen this picture drawn before, but I don't know if it's original. All the bits of the picture are certainly widely known. It helps me think about EMH.

I have made a distinction between fundamental analysis of asset values vs. buying the index/throwing darts. I'm not clear yet on where technical analysis fits in.

I have edited the above from Rowe somewhat for simplicity hopefully retaining the clarity.

3 AN ANALYSIS

We now examine the Rowe Conjecture from a slightly different perspective. Namely we look at it from that of a dynamic process which shows the interplay between the variables. Now Rowe defined the variable as follows[1]:

$$x_{People}(t) = \textit{the percent of people who believe that the EMH is true at time } t$$
$$x_{True}(t) = \textit{the probability that the EMH is true at time } t$$

Recall that the EMH simply stated is the assumption that the market value of a stock is a reflection of all the information available regarding the stock. Now we know two things. First, that there is a herd mentality in the market that make many people to believe that the stock has or does not have value independent of whatever information is available. In fact some people may have information not available to others. Second, the herd mentality is driven by a percent of those who believe the EMH whereas when the herd develops the true existence of the EMH may actually disappear.

Thus the two variables, the one being the belief in the EMH and the second being the actual operation of the EMH are related. If the true existence of the EMH is say 100% then we have an efficient market and herd mentality is at a minimal because everyone distrusts the herd and does their own analysis, assuming equality to information and equality of access to trading.

We now develop a dynamic model based on the Rowe conjectures. We have changed these variables slightly from what Rowe had stated so that they are probabilities and that they are time dependent. Now Rowe sets the problem up as a supply and demand model wherein he disregards temporal dynamics and further looks at the people percent as the quantity and the probability of validity as the price variables.

We disregard the supply demand paradigm and look at them as interlinked temporal variables. Rowe has presented a compelling model of market behavior. We build upon it and do so in a dynamic fashion.

We assume a generalized model of the following type:

$$\frac{dx_{People}(t)}{dt} = f_{People}(x_{People}(t), x_{True}(t))$$
$$and$$
$$\frac{dx_{True}(t)}{dt} = f_{True}(x_{People}(t), x_{True}(t))$$

[1] See http://worthwhile.typepad.com/worthwhile_canadian_initi/2010/01/the-supply-and-demand-for-belief-in-emh.html

Now this is a generalized model which we will add some structure to. We will do so by applying a discrete time version and then go back to the continuous time version to analyze the results in a phase plane methodology.

Let us now write:

$$x_{People}(k+1) = a_{1,1}(k)x_{People}(k) + a_{1,2}(k)x_{True}(k)$$
$$and$$
$$x_{True}(k+1) = a_{2,1}(k)x_{People}(k) + a_{2,2}(k)x_{True}(k)$$

This is a linear model. We will expand this shortly but this is a good place to commence the analysis. This simple model states the following:

1. At some time k+1, the percent of people who now believe that the EMH is true is some multiple of the percent who believe before, and this may be greater or less than one, and some percent of the probability that it is actually in force.

2. The EMH is often true if those in the market are of the belief that it is not and that the market is not reflecting the true value and that they must do their own work to seek the truth.

3. The EMH is often false, namely its presence has a low probability, if there is a herd mentality. Namely the greater the belief in an EMH the smaller the probability that an EMH is true.

4. Market Bubbles occur when the herd approaches 100% and this also means that the truth that EMH exists is reduced to zero. When a market Bubble occurs the market then is subject to collapse, and the belief in the EMH drops precipitously.

5. Thus the model should reflect the dynamic as follows:

    a. when the belief is low then the truth is high
    b. when the belief is high, it grows the level of belief to a point and then collapses the level of belief
    c. when the belief is high the truth is low
    d. truth is dependent only upon the belief, and it is the belief that solely drives the Bubble

Thus we can create a model which can be written as follows. First for truth we have:

$$x_{True}(k+1) = a_{2,1}(k)x_{People}(k) + a_{2,2}(k)x_{True}(k)$$

where

$$a_{2,2}(k) = 1$$

and

$$a_{2,1}(k) \le 0$$

and:

$$x_{People}(k+1) = x_{People}(k) + f_{1,1}(k, x_{People}(k)) + a_{1,2}(k)x_{True}(k)$$

where

$$f_{1,1} = \begin{cases} \le 0 \ if \ x_{People} \ge x_{People}^{Critical} \\ \ge 0 \ if \ x_{People} \le x_{People}^{Critical} \end{cases}$$

and

$$0 < x_{People}^{Critical} < 1$$

This leads to a continuous time system as follows:

$$\frac{dx_{True}(t)}{dt} = -\alpha x_{People}(t)$$

and

$$\frac{dx_{People}(t)}{dt} = f(x_{People}(t)) - \beta x_{True}(t)$$

and if we let the substitution in as follows:

$$x(t) = x_{People}(t)$$

then

$$\frac{d^2x}{dt^2} = f'(x,t) - \alpha\beta x(t)$$

or

$$\frac{d^2x}{dt^2} + \gamma x(t) = \begin{cases} -f_0; \frac{dx}{dt} > 0 \\ +f_0; \frac{dx}{dt} < 0 \end{cases}$$

This is the Clock equation of Andronov et al and it describes an oscillatory system in the space of x, and dx/dt. Namely we have a phase space of the two variables, orthogonal to

one another and there is a oscillatory behavior in the box as shown below. This can be simulated in discrete time by the following:

$$\frac{d^2x}{dt^2} + \gamma x(t) = \begin{cases} -f_0; \frac{dx}{dt} > 0 \\ +f_0; \frac{dx}{dt} < 0 \end{cases}$$

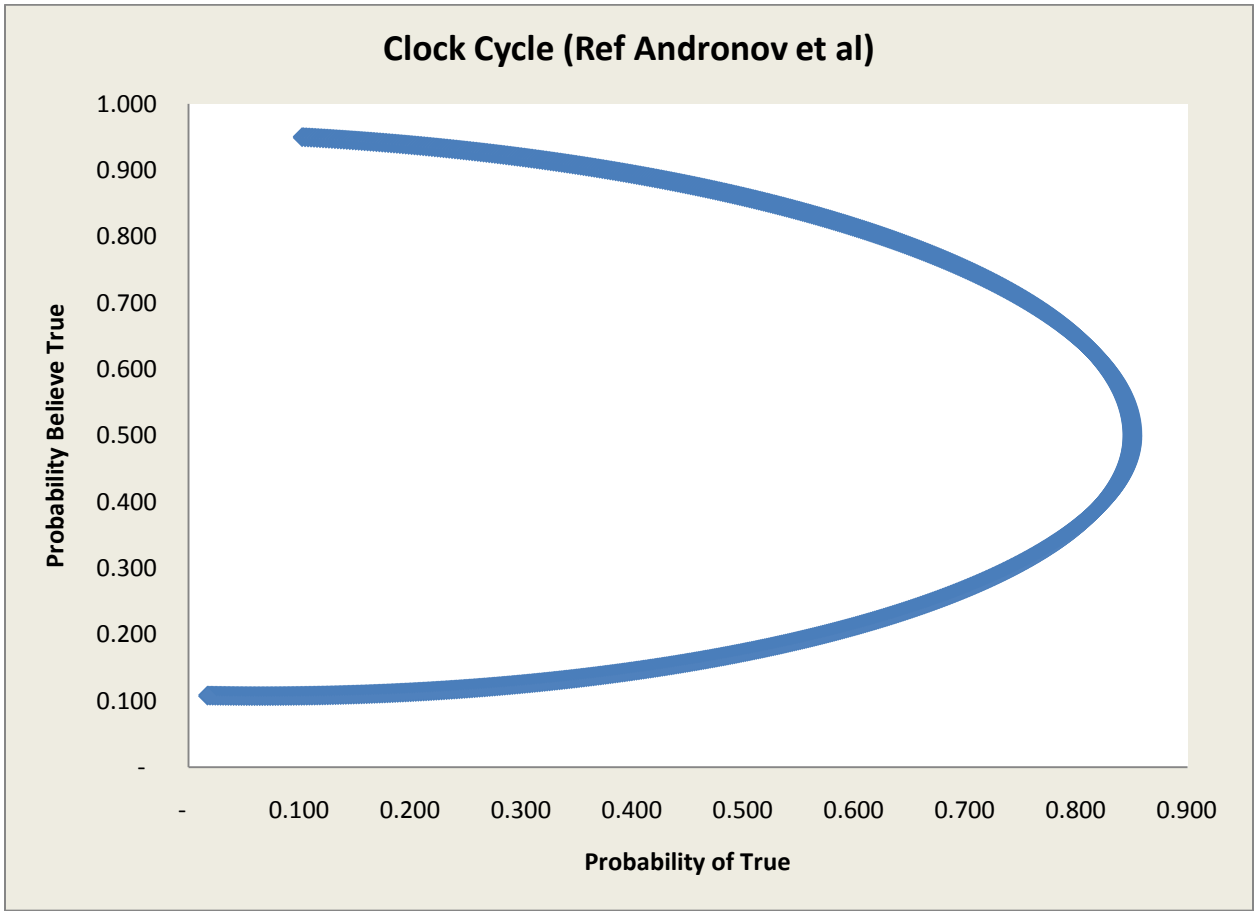
equals:

$$y(k+1) = y(k) - \gamma \Delta x(k) + \begin{cases} -f_0; y(k) > 0 \\ +f_0; y(k) < 0 \end{cases}$$

and

$$x(k+1) = x(k) + \Delta y(k)$$

The typical solution for this may look as follows:



The above is a time plot of the two variable over time and they cycle back and forth. This shows the following:

1. There can be a model for the EMH that demonstrates the relationship between the two variables. It is not a model using a supply demand model.

2. The model demonstrates market cycles as expectations and reality cycle with each other.

3. The model can be tested against real data to ascertain its validity.

It would be interesting to see how this compares with reality.

4 SOME IMPLICATIONS

Whether this model is reflective or not is still itself a conjecture. Yet the Rowe approach is compelling especially if one uses it in a time varying manner where it can depict cycles. There are some interesting implications regarding the models:

1. Reality and Perception are measured in a probabilistic fashion. There thus must be some way to determine the probability of each of these variables. For example what is the probability that the EMH is true and what does that mean and how can it be measures. The same holds true for the probability of the belief, or more properly the percent who hold the belief. On one hand this market reality question is classic in the world of finance and the belief is reflective of behavioral economics. We can readily posit these variable yet we cannot readily measure them. The classic problem is always measurement, for otherwise we are back with Alice in Wonderland, not a comfortable place to reside.

2. Cycles are dependent upon the constants and if we find a way to come to grip with the above issue then we must come to grip with the constants in the model. In writing this paper we have chosen numbers consistent with a desired result. That is self serving and yet it does demonstrate the potential of the approach. One must be able to measure the constants and validate the model.

3. Predictive validity is essential for a model. My ongoing complaint is the lack of any form of sustained predictive validity in economic models. The models are all too often like what has been produced herein, namely descriptive and presumptive, yet cannot be employed in a productive manner in an ongoing fashion.

4. Cycles are inherent in the model. The cycles show the movement between the perception and reality. The next question would be what defines a boom and a bust relative to the perception and reality plane. We can surmise that as the perception

becomes divergent from reality then the system crashes. Thus in our model above we start with total distrust in perception and reality, namely both are low, then the system builds mutual confidence, and then exuberance takes over and perception drives out reality. At the top point that is when the bubble bursts!

5 CONCLUSIONS

The Rowe model can be readily extended into a time varying analysis. We have not tried to make it overly complex and we have not tried to analytically tried to go down the path of Grossman and Stiglitz. Frankly I left that world decades ago and the results are good pseudo math but are not necessarily reflective of any reality.

In the model developed herein we use the Rowe Conjecture and in a simplified market cycle methodology and we can observe booms and busts in market bubbles as reflected in the market herding phenomenon. Perhaps this is a behavioral economics paradigm in action.

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