MODERN APPROACHES TO ASSET PRICE FORMATION: A SURVEY OF RECENT THEORETICAL LITERATURE

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ABSTRACT

In recent years, there has been much re-assessment and re-evaluation by academic economists of the Efficient Markets Hypothesis. The traditional view, stressing the ability of speculative markets to keep asset prices in line with economic fundamentals, has been challenged by an approach more sympathetic to the role of self-fulfilling expectations, psychology, herd behaviour and other seemingly irrational influences on asset prices. Greater appreciation of the institutional features of real-world asset markets also distinguishes this modern approach. The paper summarises this influential and rapidly-growing body of theoretical literature on asset price formation.

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1. INTRODUCTION

Over the past half dozen years or so there has been renewed academic interest in how prices are determined in asset markets such as stock markets and foreign currency markets. In part, this renewed interest is due to some exceptional events in those markets in the past decade and, in part, it is due to the increased interaction between market participants and academic economists. As a consequence there has been considerable re-assessment and re-evaluation of the more traditional models of asset price determination, as well as a greater appreciation by academics of the role played by institutional features of real-world asset markets. Not surprisingly, this has led to the development of a number of new theoretical models which attempt to incorporate explicitly, in an internally consistent framework, some of these more conspicuous features of contemporary financial markets. In the process, academic economists have moved closer to the views of actual market practitioners as to the key factors underlying observed asset price movements.

The mainstream of the academic literature over most of the post-war[1] period has stressed the ability of financial markets to keep asset prices moving in line with changes in their fundamental determinants. It has been unsympathetic to market and popular views that emphasised the role played by such factors as self-fulfilling expectations, mass psychology, herd behaviour and other seemingly irrational behaviour in influencing asset price movements.

The formal statement of the mainstream academic position was embodied in the Efficient Market Hypothesis (EMH)[2], which postulates that all information relevant

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[1] Seminal contributions in establishing the predominant post-war view were Friedman (1953), Samuelson (1965) and Fama (1970).

[2] Fama (1970) is generally credited with introducing into general usage the term *efficient capital markets*. Fama's general definition of asset market efficiency was that the asset prices arising from such a market fully reflected all of the information in some relevant information set. He went on to distinguish three versions of the concept of market efficiency depending on the

to determining the intrinsic value of an asset will, by virtue of the actions of rational, profit-maximising traders, be embodied in the actual market price. As a consequence, asset prices will fully reflect all relevant information, and will move only upon the receipt of new information. If asset markets do not act as efficient aggregators and processors of relevant information, the resulting disparity between market prices and intrinsic values would present traders with easily identifiable and riskless profit opportunities. In exploiting such opportunities (i.e. purchasing underpriced assets and selling overpriced ones), rational speculators would quickly drive asset prices back towards their intrinsic values, thereby having a stabilising influence on asset markets. Speculators who did not behave in this manner - that is, investors whose conduct may be characterised as irrational and destabilising - would make losses and be forced to exit the market.

While there are many other implications of the EMH, some of which would receive the support of market participants as well as academic economists, there are at least two aspects which have never been accepted by market participants:

- the implication that the price of an asset moves *if and only if* the market receives new information on the asset's underlying economic fundamentals; and
- that the actions of speculators must be stabilising, in that they move the price of an asset towards its intrinsic value rather than away from it.

Market participants have always been conscious of the importance of other influences on asset prices, but they have not been very rigorous in articulating their views. Proponents of the EMH concede the existence of these additional influences but have tended to regard them as of minor or passing importance. Sustained rises in prices, apparently inexplicable in terms of changes in market conditions, have been around since the times of Dutch "Tulipmania" of 1636 to 1637 and the South

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particular specification of the "information set". These were (i) "weak-form efficiency", (2) "semistrong-form efficiency" and (3) "strong-form efficiency" corresponding to information sets which contain respectively only (i) past prices and returns, (ii) all publicly available information, (iii) all information, both publicly available as well as "insider" or private information.

Sea and Mississippi bubbles of 1719 to 1720[3], but they have never had much of an effect on academic views because they were difficult to formalise in an internally consistent theoretical framework.

This state of affairs has begun to change. Academic economists are increasingly recognising that there are several important features of trading in modern asset markets which can be quantified and formalised, and which are clearly contrary to the sort of behaviour implied by the EMH. For example:

- the widespread use of *chartism* and *technical analysis* assumes that publicly available information, such as past asset price movements, can be profitably exploited to predict future movements in an asset price. If the EMH fully explained behaviour in asset markets, chartism should die out, yet its importance seems to have increased in some markets.[4]

- the extensive use of *stop-loss orders*, i.e. selling orders which are activated once the asset price has fallen by a certain pre-determined amount. This means that, rather than buying an asset as its price falls, investors trigger additional selling and so push the asset price down further. Past movements in price can therefore influence future asset price movements.

- the growth of dynamic hedging strategies such as *portfolio insurance*, which involve investors selling into a falling market and buying into a rising one.

Each of these practices or strategies involve basing investment decisions on past movements in price. Their presence is also consistent with the view that investors in asset markets can often behave in a destabilising manner.

The central issue is whether these "real world" characteristics of contemporary asset markets are important enough to have a significant effect on asset price behaviour, or whether they cause minor and temporary aberrations. If the latter, there would be

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[3] For an excellent account and discussion of these and other major episodes of speculative manias and financial panics see Kindleberger (1989).

[4] Frankel and Froot (1990a) report on the type of models employed by foreign exchange forecasting services. In a survey conducted in 1978, only 2 out of the 23 used chartism and technical analysis, while in 1989, the proportion had increased to 18 out of 31. Allen and Taylor (1990) reports the results from a survey of London foreign exchange dealers conducted on behalf of the Bank of England; at least 90 per cent of the respondents attached some weight to chartist methods and technical analysis.

little need to review economists' formal models of asset pricing. In recent years, however, several events suggested that destabilising behaviour in asset markets could have far reaching implications for asset prices and that a serious rethinking of asset price determination was in order:

- in the two years to early 1985, the US dollar appreciated by about 40 per cent, and then depreciated by about the same amount over the following two years. Examination of factors usually thought of as relevant to the determination of the exchange rate has not identified anything that could give rise to a movement of this magnitude.

- on 19 October 1987, US stock prices fell by 22 per cent on the one day. Again, no one can identify any important economic news at the time that could account for a fall of this size.

- the Japanese "*Bubble Economy*", a term used to describe the Japanese economy in the second half 1980s when it was gripped by feverish asset speculation. Some commentators have begun to characterise this as the most extreme episode of financial mania witnessed this century.[5]

These events brought home the fact that even in very deep and well-informed markets, it was possible to have large price movements, lasting for months or even years, that could not be explained in terms of the EMH framework. It also led to the re-interpretation of earlier events such as the bull market in US stocks that took the Dow to the 1000 level in January 1966, where it languished for seventeen years before it decisively exceeded that barrier again in 1983. How could rational investors have pushed stock prices so high that, in aggregate, they would not exceed these values again for seventeen years, even though other relevant nominal variables such as output, producer prices, and profits continued to grow?[6]

As stated earlier, the two most troubling characteristics of the EMH were the implication that future prices are not influenced by past movements in the asset price, and that speculation can have only a stabilising influence upon asset markets. While these two characteristics are interrelated, they can be thought of separately for expository purposes.

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5 See Wood (1992).

6 See Kurz (1992).

On the first point, it is clear that past prices do influence the behaviour of investors and traders. As well as the mechanical influences listed above such as chartism, stop-loss orders and portfolio insurance, there are more fundamental ones based on human behaviour. Typically, many investors do not enter a market as buyers until after they have heard of the fortunes being made there - that is, until after it has already risen. The influx of buyers into the Australian share market in the latter stages of the "minerals boom" of the late sixties is an example of this. Greed is not always the motivation; sometimes it is fear. Many people, who had been content to rent houses when house prices were relatively stable, fear that they might be permanently priced out of the market when house prices begin to rise sharply. They thus enter a rising housing market as buyers.

The concept of a market price that returns to its intrinsic (or underlying) value as the result of the activities of speculators (or arbitrageurs) also has its difficulties. The major one is that in some markets there is no satisfactory model of what the underlying price should be. In the bond market, models of the underlying price are fairly well defined and accepted, but there is a spectrum of other markets for which the models become less and less clear. The foreign exchange market is probably at the other extreme. Economists have not been able to explain variations in the exchange rate with any degree of precision. Neither can they forecast it a year ahead, even in the hypothetical case in which they use the actual values of the explanators.[7] If the experts cannot tell what the equilibrium value should be, or even what variables should determine it, how are market participants able to move the price toward the equilibrium value? Also, how are economists to know, after the event, whether any movement initiated by speculators was in the direction of the intrinsic value, or away from it?

The purpose of this paper is to survey the rapidly burgeoning literature which attempts to come to grips with some of the phenomena outlined above. As would be expected, the main purpose of the literature has been to provide sound theoretical arguments as to why asset markets may display behaviour not in accordance with the central propositions of the EMH - specifically why they sometimes show departures from, what subsequently turn out to have been, their intrinsic values.

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[7] See Meese and Rogoff (1983) and Meese (1990).

There are several appealing features of this new view of asset markets, apart from the fact that they permit the possibility that observed asset prices will not always be at their equilibrium. Some of these models incorporate the behaviour only of investors who behave rationally, while others incorporate different groups of investors some of which behave rationally and others in an irrational way. This degree of realism is clearly desirable, partly because this literature comes to the conclusion that "bubbles" are quite consistent with rational behaviour. A further important strand of this group of models concerns the way that information is processed and analysed in asset markets, including the information content of trading behaviour.

For purposes of this survey, the literature is classified into the following three strands:

(i) rational speculative bubbles, which are dealt with in Section 2;

(ii) fads, irrational Bubbles, and noise traders, in Section 3; and

(iii) inefficiencies that are due to imperfect and heterogenous information, in Section 4.

Section 5 is the Conclusion.

2. RATIONAL BUBBLES

2.1 Theoretical Development

The theory of "rational bubbles" represents one important strand of the literature that has developed to explain divergences of asset prices from their fundamental or intrinsic values. It was the academic community's first attempt to rigorously challenge key propositions of the EMH. It demonstrates that, even with rational expectations and behaviour, "rational" deviations in asset prices from their intrinsic values - a *rational bubble* - would be possible.[8]

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[8] Important contributions include those of Blanchard (1979), Blanchard and Watson (1982), Flood and Garber (1980) and Tirole (1982, 1985). For a detailed and more technical discussion see Chapter 5, Blanchard and Fischer (1989).

Simply stated, a *rational bubble* is present whenever an asset price deviates progressively more quickly from the path dictated by its economic fundamentals. The growth of rational bubbles reflects the presence of *arbitrary* and *self-confirming expectations* about future increases in an asset's price. They would be a feature of a market in which an investor purchases an asset solely in anticipation that it could be resold at a higher price to another investor willing to purchase the asset for the same reason. Thus, an explosive divergence from fundamentals would be possible even if economic agents always held rational expectations and rational arbitrage conditions were satisfied.

The potential for rational speculative bubbles exists in the large class of dynamic asset pricing models, in which the equilibrium price in the current period depends on expectations about future changes in the asset's price. In these models, such bubbles can emerge if expectations are rational and the current equilibrium price depends positively on its own expected rate of change.

These models of rational speculative bubbles are indeterminate. In other words, they have an infinite number of equilibrium solutions. The indeterminacy comes about because asset pricing models with such a structure essentially possess only one condition to constrain asset market equilibrium and rationality of expectations, whereas the model's solution dictates solving for two endogenous variables - the current equilibrium asset price and its expected rate of change - in each period.[9] Thus, in these models, there can exist a multiplicity of asset price solutions or trajectories, of which only one corresponds to the economic fundamentals; the other trajectories will all contain asset price bubbles.

To see most simply how rational bubbles can arise, consider the following asset price expression:[10]

$$x_t = \quad z_t + \ a.[E(x_{t+1} - x_t)|I_t] \qquad (1)$$

where x_t is the (logarithm) of the equilibrium asset price at time t; z_t represents a scalar measure of current period "fundamentals" affecting the asset price, i.e. the

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9 See Flood and Garber (1980) and Flood and Hodrick (1990).

10 Frenkel and Mussa (1985) argue that a diverse range of structural models of exchange rate determination can be subsumed under this reduced form asset-price expression.

economic conditions of supply and demand; $[E(x_{t+1}\text{-}x_t)|I_t]$ represents the expected percentage rate of change of the asset price between period *t* and *t+1*, conditional on all information currently available, I_t; and a is a positive constant representing the elasticity of the current asset price with respect to market expectations.

Equation (1) states that the spot asset price in any period is determined by the current period "fundamentals" and the prospective capital gain or loss from holding the asset until the next period. It embodies rational expectations, since the expectation is the mathematical expectation of the change in the asset price based on all information currently available.[11]

Re-arranging equation (1) gives:

$$x_t = \frac{1}{(1+a)} . z_t + \frac{a}{(1+a)} E[x_{t+1}|I_t] \qquad (1a)$$

This is a stochastic difference equation in the asset price, with the fundamentals, z_t, acting as the "forcing" process. Applying the "law of iterated expectations"[12], equation (1a) can be solved recursively forward *T* periods, yielding the following expression:

$$x_t = \frac{1}{(1+a)} \sum_{i=0}^{T} \left(\frac{a}{1+a}\right)^i E[z_{t+i}|I_t] + \left(\frac{a}{1+a}\right)^{T+1} E[x_{t+T+1}|I_t] \qquad (2)$$

A *particular* solution to the stochastic difference equation (1a) is given by:

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[11] In addition to this assumption that the expectation is the *mathematical expectation*, two other assumptions are implicitly made in defining rational expectations. First, everyone possesses or observes the same "information set" at time *t*, i.e. I_t is common to all economic agents. Second, there is agreement among all economic agents as to what constitutes the underlying economic model, as well as full knowledge of its parameter values.

[12] Formally, if the information set I_t is a subset of the information set I_{t+1} then $E\left[E\left[x|I_{t+1}\right]|I_t\right] = E\left[x|I_t\right]$. This basically states that the *expected value today* of *next period's expectation* of the random variable *x*, is the same as *today's expectation* of the same variable *x*.

$$x_t = \frac{1}{(1+a)} \sum_{i=0}^{\infty} \left(\frac{a}{1+a} \right)^i . E[z_{t+i} | I_t] \equiv x_t^* \quad (3)$$

Equation (3) defines the *fundamental* or intrinsic value of the asset price at time t, denoted as x_t^*. The fundamental spot price of the asset at time *t* is an exponentially weighted sum of present and expected future values (conditional on the information set available in period t) of all relevant economic fundamentals.

However, x_t^* is the unique solution to the difference equation (1a) if, and only if, the following condition is satisfied:

$$\lim_{T \to \infty} \left(\frac{a}{1+a} \right)^{T+1} E[x_{t+T+1} | I_t] = 0 \quad (4)$$

Condition (4), sometimes referred to as a transversality condition, is regularly assumed, though in most instances, there is no *a priori* justification for its imposition. If the transversality condition does not hold, then the stochastic difference equation (1a) has an infinite number of solutions of which only one corresponds to the fundamental solution x_t^*.

The *general* solution to the stochastic difference equation (1a) is given by a set of solutions of the form:

observed asset price = fundamental value + rational bubble

More precisely, each solution may be expressed as:

$$x_t = x_t^* + b_t \quad (5)$$

where x_t^* is given by equation (3) above, and b_t satisfies the condition:

$$b_t = \left(\frac{a}{1+a} \right) E[b_{t+1} | I_t] \quad (6)$$

or equivalently,

$$E[b_{t+1}|I_t] = \left(\frac{1+a}{a}\right).b_t \qquad (6a)$$

The stochastic process b_t is defined as the *rational bubble* component of the asset price, and is simply the difference between the actual price at time t and its intrinsic value determined by prevailing economic fundamentals. Condition (6) above states that, for a bubble to be a viable outcome, it must reflect the expectation that it will continue to expand in the following period.[13] If the transversality condition holds, then $b_t = 0$, which implies that the observed price corresponds with its long-term equilibrium value. Thus, a common theoretical interpretation of rational speculative bubbles is as a violation of the transversality condition.

2.2 Deterministic and Stochastic Bubbles

In its simplest (and least plausible) form, a rational bubble may follow a deterministic time path, with deviations from fundamentals growing exponentially. An example of such a deterministic or ever-expanding bubble is:

$$b_t = \left(\frac{1+a}{a}\right)^t.b_0 \qquad (7)$$

In equation (7), b_0 is an arbitrary non-zero constant. This equation implies that the asset price will diverge explosively forever from its intrinsic value - a highly improbable event.

Blanchard (1979) and Blanchard and Watson (1982) advanced a more realistic model. Referred to as *rational stochastic bubbles*, these have the feature of growing over a certain interval, before suddenly collapsing. The following stochastic process illustrates:

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[13] Note that projecting into the infinite future, the rational bubble component explodes in expected value:

$$\lim_{i \to \infty} E[b_{t+i}|I_t] = \left(\frac{1+a}{a}\right)^i b_t = \begin{cases} +\infty & if \quad b_t > 0 \\ -\infty & if \quad b_t < 0 \end{cases}$$

$$b_{t+1} = \left(\frac{1+a}{p.a}\right).b_t + e_{t+1} \quad \text{with probability } \pi$$

$$= e_{t+1} \quad \text{with probability } (1 - \pi) \qquad (8)$$

where the bubble "innovation" e_{t+1} satisfies $E[e_{t+1}|I_t] = 0$

Under this formulation, there is a probability, π, that a bubble will survive until the next period and a probability, $(1 - \pi)$, that it will crash in the current period. If the bubble crashes, the asset price will return to its intrinsic value. The "innovation" term e, implies that a bubble can regenerate itself after crashing; the stochastic bubble can thus burst and restart repeatedly.

This bubble structure can also be extended to allow for certain features that have been observed in speculative asset markets. Blanchard and Watson (1982) suggest that the specification of π, the probability of the bubble's survival, could be refined. It could, for example, have stochastic properties and be determined by such factors as the length of time the bubble has lasted, or the deviation in the asset price from its fundamental value. An alternative approach would be to model it as a function of fundamental variables, such as "news" about key economic aggregates.

2.3 Are Rational Bubbles Rational?

Blanchard and Watson conclude that the persistence of such stochastic bubbles remains compatible with the postulate of rational expectations. Although rational investors can be certain that a bubble will ultimately collapse, they will always be uncertain about the timing of any crash. Consequently, they may continue holding an asset in the hope of realising even larger capital gains from further rises in its value. At the beginning of each period, rational investors will decide whether to liquidate their positions, and take profits, or to continue holding their positions in anticipation that the bubble will survive and yield even larger (unrealised) capital gains. They will choose the latter course if they expect to be compensated - by a higher expected rate of growth in the asset price bubble - for taking the chance that the bubble will collapse. It is for this reason that the expected rate of growth of a

stochastic rational bubble, if it survives, is greater than that of a deterministic rational bubble.[14]

The extent to which such rational bubbles are truly consistent with rationality is an issue which has attracted considerable attention in the academic literature. Contributions by Tirole (1982, 1985) as well as Diba and Grossman (1987, 1988), identify conditions which would preclude the emergence of rational bubbles in dynamic asset pricing models. Tirole (1982) demonstrates that rational bubbles cannot develop when (i) the asset has a finite life, and hence a definite terminal value[15] or (ii) if there exist a finite number of traders, who have rational expectations and optimise over an infinite horizon.[16] Tirole (1985) shows that, in an overlapping generations framework, in which there exists an infinite succession of new (finite-horizon) traders coming into the market, rational bubbles can exist provided the economy is dynamically inefficient. By this, it is meant that the rate of growth of the economy exceeds the rate of interest. If this condition is violated, however, there will exist a point in time where the wealth of new asset holders will be insufficient to purchase the asset upon which a bubble has developed.

Diba and Grossman show that in such models, if a rational asset price bubble does not exist in period *t*, then it cannot get started in period *t*+1 nor in any other subsequent period. As a consequence they argue that, if a rational asset bubble

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[14] Observe that $\left(\frac{1+a}{p.a}\right) > \left(\frac{1+a}{a}\right)$

[15] To see this let T be the terminal date of the asset and x_T^* its terminal value. In period *T* the price of the asset will be equal to its terminal value and hence no bubble will exist i.e. $x_T = x_T^* \Rightarrow b_T = 0$. However rational expectations dictate that if no bubble exists in period *T*, then none will exist in period *T*-1; rational investors will not pay more than the discounted terminal value of the asset, x_T^*, in period *T*-1. Proceeding with a such a backward induction argument it logically follows that a rational bubble cannot exist in period *T*-2, nor in period *T*-3, nor in any other preceding period including period 0. That is to say, a rational bubble will never arise.

[16] This argument is based on a view that trading is a *zero-sum game.* From an aggregate perspective, the real worth of an asset is, by definition, equal to its fundamental value. In a market with a finite number of traders, some traders may be able to sell their asset holdings at bubble prices but the buyers will be worse-off. If investors who have sold at a price above fundamentals, then exit the market, remaining traders will be involved in a *"negative-sum game"*. Tirole argues that rational investors would recognise this problem, thereby ensuring that an asset price bubble would not emerge to begin with.

exists, it must have started on the first day of trading.[17] One implication of this is that a rational bubble could not restart once it had collapsed.

2.4 Intrinsic Bubbles

In the original formulation of rational speculative bubbles, the "bubble" component was completely divorced from the "fundamental" component, and was driven entirely by extraneous variables. Recent theoretical contributions by Froot and Obstfeld (1991) and Ikeda and Shibata (1992), however, re-examine the relationship between the bubble and fundamental components of dynamic asset pricing models.

Froot and Obstfeld (1991) demonstrate the possibility of a distinct class of rational bubbles which they refer to as "intrinsic bubbles". Unlike the rational bubbles discussed above, intrinsic bubbles do not depend on arbitrary and extraneous factors, but instead are specified as being *deterministic non-linear* functions of the asset's fundamentals. This sort of bubble process has a number of properties which make it a more plausible description of the departure of asset prices from their intrinsic value. Specifically, in this class of model:

- departures from fundamental values can persist, and appear stable, for long periods of time, so that stable economic fundamentals can be associated with stable and persistent under/overvaluations of asset prices;
- asset prices can overreact to "news" about the fundamentals; and
- asset prices can converge to their fundamental value and then diverge, giving the appearance of periodically bursting and restarting.

Ikeda and Shibata (1992) also propose a bubble which depends on fundamentals but in which the economic fundamentals are *stochastic*; current fundamentals affect rational investors' expectations about market conditions and, hence, future asset prices. Ikeda and Shibata (1992) demonstrate that their "fundamentals-dependant bubbles" are qualitatively distinct in several respects from traditional models of

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[17] Note that if $b_t = 0$ at some date t then from condition (6a) above it follows that $E[b_{t+1}|I_t] = 0$. However, with the assumption of "free disposal" (i.e. investors can always "walk away" from their investment in an asset) b_{t+1} is a non-negative random variable i.e. $b_{t+1} \geq 0$. Therefore, from the above two propositions, it follows that if $b_t = 0$ then $b_{t+1} = 0$ with probability one.

rational bubbles. In particular, these bubbles may periodically contract and expand, and display monotonic declines in both magnitude and volatility. Furthermore, the sign of the bubble's correlation with the fundamentals varies over time. When this correlation is negative, the bubble-inclusive asset price displays less volatility than the asset's fundamental value.

While the theory of rational speculative bubbles provides one explanation of departures in asset prices from their fundamentals, it has some drawbacks. One significant deficiency is that the "microstructure" of the bubble process is seldom, if ever, specified. Both the inception and collapse of a rational bubble is taken as exogenous. Thus the conditions and mechanism by which such bubbles can be generated, and the events contributing to their sudden collapse, are not spelled out in any satisfactory way, if at all. Moreover, these models imply that there exists an infinite number of equilibrium price trajectories, only one of which is consistent with the economic fundamentals. The theoretical framework thus implies that an observed asset price will rarely correspond to its intrinsic value - for some, an unattractive characterisation of real-world asset price movements. As a consequence of these deficiencies, alternative theoretical frameworks have been developed, especially ones which relax the assumption that all investors and traders are rational. These models are covered in the next section.

3. FADS, IRRATIONAL BUBBLES, AND NOISE TRADERS

In this strand of the literature, there are at least some investors and traders whose sentiment and expectations are driven by extraneous or non-fundamental factors such as fads, fashions, rumours and "noise". The participation of such a group of investors can disrupt and destabilise speculative asset markets; they may generate excessive volatility in asset prices and contribute to the more severe episodes of financial market instability, colourfully described by some as "speculative manias", "frenzies", "irrational speculative bubbles", "panics" and "crashes".[18]

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[18] See Kindleberger (1989) and also Malkiel (1990).

The view that prices in speculative asset markets might at times be influenced by irrational investor behaviour, while not new[19], first found influence with the contributions of Robert J. Shiller. Building on his earlier empirical work dealing with "excessive" volatility in stock prices, Shiller (1984) and (1989) emphasised the importance of *mass psychology* in financial markets, in particular the role played by investors' susceptibility to "fashions" and "fads". According to Shiller, changing fashions, fads, and erratic and capricious shifts in investor sentiment, have been the chief causes of mispricings of assets.

This theory of asset price dynamics is now simply referred to as the "fads" model of asset prices. A fad is defined as any departure of asset prices from their fundamental values due to socially, or psychologically, induced changes in market sentiment and opinion. Unlike a rational speculative bubble, however, in these models the asset price does not deviate from its fundamental value in an explosive manner.

To help understand the dynamics of fads, Shiller finds useful mathematical models of epidemics and contagion which some sociologists have employed in their analysis of the spread of news and rumour. Such diffusion models describe how a fad develops by specifying an "infection rate" - the rate at which interest in a fad spreads among a population - and a "removal rate" - the rate at which interest dissipates. Other variables, such as the number of "carriers" and the size of the "susceptible" population, are also relevant. Thus, Shiller states: *"A fad is a bubble if the contagion of the fad occurs through price; people are attracted by observed price increases. Observing past price increases means observing other people*

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[19] Nurkse (1944) for example, maintained that the documented excessive volatility and instability of currencies during the inter-war period of the 1920s and 1930s was due primarily to irrational destabilising currency speculation. He argued that as a consequence of irrational and extrapolative expectations on the part of currency speculators, small fluctuations in the exchange rate would induce large and self-reinforcing movements of the currency in the same direction. Speculation in foreign currency markets was thus perceived by Nurske as a destabilising influence, accentuating and prolonging what otherwise would be small and short-term fluctuations of a currency around its long-run equilibrium value. See also Keynes' (1936) incisive and pertinent observations on the nature of speculative activity and of financial markets in general, in Chapter 12 of *The General Theory*.

becoming wealthy who invested heavily in the asset, and this observation might interest or excite other potential investors".[20]

Shiller dismisses one critique of fads advanced by proponents of the EMH. These proponents argue that the actions of rational arbitrageurs will negate the influence of fads by exploiting large, riskless profit opportunities associated with them. According to Shiller, this argument reflects a misunderstanding of the relationship between the ability to forecast asset returns and market efficiency. While market efficiency implies that changes in asset prices cannot be forecast, the inability of investors to forecast asset prices does not necessarily imply market efficiency (in the sense that observed prices will always equal their intrinsic values). Shiller concludes that, if the future path of a fad is unpredictable, even rational investors would be unable to profit from the discrepancy between observed asset prices and their fundamental values.

Following Summers (1986) formalisation of Shiller's "fad" concept, a fad in an asset price may be represented by the following expression:

$$x_t = x_t^* + F_t \qquad (9)$$

$$\text{with } F_t = \lambda F_{t-1} + e_t$$

where x_t is the log of the asset price at time t; x_t^* is the *fundamental value* of the asset at time t (given by equation (3) above); F_t is the *fad* in the asset price; λ is a parameter measuring the rate of decay of the fad; and e_t is a stochastic disturbance term with zero mean.

In this approach, the asset price is modelled as the sum of a random walk (the fundamental component) and a *fad* component which, while it is assumed to persist, is not assumed to diverge indefinitely (i.e $0 \leq \lambda < 1$).[21] Shiller (1984) and Summers (1986) observe that, with such a specification, inability to forecast asset returns over the short run and large departures of prices from their fundamentals would not be

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[20] Shiller (1989, p. 56).

[21] Note that, if $\lambda = \left(\frac{1+a}{a}\right)$ the fad component will be identical to a rational speculative bubble leading to the asset price diverging explosively from its fundamental value.

inconsistent. This is because the fad component, F_t, would follow a stochastic process similar to a random walk, while retaining the property of mean reversion.

3.1 The Noise-Trader Approach

Friedman's (1953) contribution, referred to in the Introduction, contained the central tenet of the EMH that rational speculation will stabilise asset prices and drive out irrational or destabilising speculation. Recent contributions have subjected this view to a forceful attack, notably within the "*noise trader*" approach. Seminal and representative papers include De Long, Shleifer, Summers and Waldman (1990a, 1990b, 1991); Cutler, Poterba, and Summers (1990, 1991); and Shleifer and Summers (1990). The noise-trader approach is gaining wider acceptance in the economics and finance literature.

Two propositions lie at the core of the noise-trader framework:

(i) *the co-existence of heterogeneous investors and traders*

The noise traders approach explicitly acknowledges the interaction of two qualitatively distinct categories of trader/investor. One category comprises traditional rational speculators, also referred to as "*arbitrageurs*", "*smart money*" or "*fundamentalist*" traders. These are sophisticated investors whose opinions and trading decisions are based on economic fundamentals and who strive to digest all relevant economic information when making investment decisions. They are also assumed to be *risk averse* and have relatively *short trading horizons*.

Trading decisions of the other category of investors - "*noise-traders*"[22] - display a degree of irrationality. This category of "unsophisticated" investors is not as well informed as rational investors and is highly susceptible to fads, rumours and other extraneous information ("noise"). Attitudes of noise traders

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[22] The introduction of this term into the literature is attributed to Black (1986) and Kyle (1985). Black (1986) defines "noise" as essentially the antithesis of information: "Noise trading is trading on noise as if it were information. People who trade on noise are willing to trade even though from an objective point of view they would be better off not trading. Perhaps they think the noise they are trading on is information. Or perhaps they just like to trade." Black (1986, p. 531).

are thus highly correlated and their opinions cannot be fully justified by economic fundamentals. Their activity can therefore generate shifts in aggregate demand for the asset which cannot be fully explained in terms of the fundamentals.

(ii) *arbitrage limitations*

In the noise-trader model, the degree of arbitrage activity undertaken by rational investors is limited, and unable fully to counteract demand shifts generated by noise traders. In these models rational investors are typically assumed to be risk averse, in relation to:

- *fundamental risk*, i.e. the risk of loss due to unexpected changes in an asset's fundamentals. For example, after evaluating relevant information, a rational investor may be convinced that an asset is definitely "overvalued" today. The investor may be reluctant to sell heavily at that price, however, because of the risk that fundamentals will move against him. Unanticipated information reflecting favourably on the asset may be released in future periods, raising the fundamental value and thereby generating a loss on the trade undertaken today.

- *noise trader risk*, i.e. the possibility of erratic shifts in asset demand due to the unpredictable and capricious nature of noise trader expectations. This can increase uncertainty about the future price of an asset, thereby adding to risk borne by rational arbitrageurs. For example, suppose that, due to noise-trader demand, an asset is considerably undervalued relative to its fundamentals. Arbitrageurs contemplating buying the asset cannot ignore the possibility that, by the time they have to liquidate their positions, noise traders will have become even more "bearish" and pushed the price even lower. This would clearly limit the size of the initial position that a risk-averse rational investor would be prepared to take.

- *uncertainty about fundamentals*, i.e. individual rational investors may be uncertain about whether an observed movement in an asset price is due to changes in noise trader demand or to new information about fundamentals. Perfect arbitrage presumes that rational investors know with certainty the fundamental value of an asset and can accurately determine whether it is undervalued or overvalued. A more realistic view is that rational investors

> do not have absolute confidence in their estimates of the fundamental value, or their ability to discern even significant mispricings of assets.[23]

The limited appetite of rational speculators for arbitrage also reflects the assumption that rational speculators have *short-term investment horizons*. Two reasons are advanced for this assumption:[24]

- the performance of most portfolio and pension fund managers' is evaluated over a relatively short term. Funds managers therefore have a strong incentive to focus on factors affecting the short-term performance of a portfolio. Factors bearing on the fund's longer-term performance will tend to have less importance.

- capital market imperfections reflecting, say, asymmetric information, may limit the borrowing capacity of rational speculators. Limited access to capital and other such credit restrictions, might mean that long-term arbitrage positions cannot be maintained indefinitely or would be very expensive compared with short-term arbitrage opportunities.

The noise-trader approach is a more realistic description of asset markets than earlier models of asset pricing since a group of irrational investors co-exists with a group of rational investors, and the arbitrage activities of the latter are limited. This implies that arbitrage activity by rational speculators might not be sufficient to eliminate fully the influence of noise traders, but can nonetheless move asset prices at least partially towards their fundamental values.

3.2 Destabilising Rational Speculation

A variation of the noise trader approach describes situations in which trading by rational speculators might actually exacerbate price movements arising from the

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[23] In light of the large number of alternative and empirically unsuccessful models of exchange rate determination, this problem of accurately assessing fundamental value is particularly acute in the foreign currency market. Witness, for example, the negative assessment by Meese (1990, p. 118): "The proportion of (monthly or quarterly) exchange rate changes that current models can explain is essentially zero. ... The economics profession has not yet reached a consensus on the appropriate set of fundamental factors to include in an exchange rate equation".

[24] Tuckman and Vila (1992) show that holding costs or unit time costs can also discourage the maintenance of long-term arbitrage positions by rational risk averse traders.

activities of noise traders. De Long, Shleifer, Summers and Waldman (1990b) demonstrate how rational speculators will find it in their interest to exploit the presence of *positive feedback* elements in the market. In this case, activity by rational investors might induce deviations of asset prices from their fundamental values beyond those due to the activity of noise traders. Contrary to the conclusion of Friedman (1953), rational speculation could have a destabilising impact on asset prices.

Positive feedback strategies involve purchasing an asset after it has appreciated in value or selling it after it has depreciated. Trading activity based on this strategy is quite common in asset markets, and may be prompted by a number of investment approaches, including "chartism" and technical analysis, "stop-loss" orders, portfolio insurance and extrapolative price expectations.[25] Positive feedback effectively reinforces and perpetuates the direction of asset price movements and generates "momentum". De Long *et al*. (1990b) demonstrate that such momentum will be exploited by profit-maximising rational speculators, thereby accentuating asset price volatility.

The way in which interaction between sophisticated rational speculators and unsophisticated positive feedback traders (essentially noise traders) can generate asset price instability can be illustrated by the following scenario. Suppose that

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[25] Contributions by Frankel and Froot (1986, 1988 and 1990b) on the formation of actual expectations in the foreign exchange market are indicative of the substantial presence of positive feedback trading. Based on extensive survey data of investors expectations on the US dollar and the Japanese yen, Frankel and Froot document how over the "short term"(1, 2, and 4-weeks ahead) expectations are extrapolative i.e. exhibit significant "bandwagon" tendencies. On the other hand, over the "long term"(3, 6 and 12 months ahead) expectations were heavily influenced by currency fundamentals. Examination of forecasts and recommendations of leading exchange rate forecasting services during mid 1980s, when the US dollar was generally perceived to be overvalued, supported this conclusion. The typical forecaster maintained that the dollar was overpriced relative to its fundamentals and was expected to depreciate within a 12 month period, but was still issuing "buy" recommendations for the currency over the short term.

Allen and Taylor (1990) document that the formation of short term exchange rate expectations is heavily influenced by chartist/technical analysis. Survey evidence compiled from major participants in the London foreign exchange market revealed that 90 per cent of the respondents used some form of technical analysis in assessing the future direction of the exchange rate over the short run. For horizons of a one year and longer, 85 per cent of respondents viewed fundamentals as being considerably more important.

sophisticated rational speculators receive some "bad" news about an asset's fundamentals. Recognising that any fundamental-based selling that they might undertake today will cause positive-feedback selling of the asset tomorrow, sophisticated speculators may initially sell excessively large amounts of the asset causing its price to fall by far more than is warranted by the deterioration in fundamentals. Positive feedback traders might then observe the large price fall and react by also selling the asset, causing its price to fall yet further. Rational speculators can then close their short positions to realise a profit.

In summary, unfavourable news which would have dictated some fall in an asset's intrinsic price, would - as a result of sales by rational speculators anticipating positive-feedback trading - lead to a substantially larger fall in the asset price than could be justified by the fundamentals. Rather than offsetting noise trader behaviour, the behaviour of rational speculators would magnify its impact, at least in the short term.

Advocates of the EMH claim that, by virtue of their trading behaviour, noise traders will incur large losses and be forced to exit the market. The presence of noise traders will therefore only have a very marginal influence on asset prices. In response, proponents of the noise trader approach advance several reasons for the survival and persistence of noise traders:

- noise traders tend to make erroneous assessments about an asset's return and its riskiness (i.e. they tend to overestimate returns and/or underestimate risk). They are therefore likely to be more "bullish", on average, than rational speculators, and willing, on average, to bear more risk. Since asset markets compensate investors who take on more risk with higher rates of return, it is possible that expected returns to noise traders will be higher than those of rational speculators, even though they would, on average, be purchasing overpriced assets and selling underpriced ones. This reward might not necessarily reflect the bearing of "fundamental risk"; the higher return to noise traders might simply reflect compensation for accepting more of the risk which they themselves have introduced.[26]

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[26] De Long *et al.* (1990a, p. 74).

- successful noise traders, and the strategies they employ, will attract new traders adopting similar strategies. These recruits might erroneously attribute the higher average returns earned by noise traders to skill, rather than greater risk-taking and luck.

- there is a continual influx of new traders and investors in asset markets. A sizeable proportion of these are likely to embrace unsophisticated investment strategies, including noise trading. Furthermore, noise traders who incur losses and are forced to exit the market, may save and return to the market at a later point in time, still adhering to their noise-trader strategies.

The long-run viability of noise traders, and their impact, cannot therefore easily be dismissed. Their presence can be an important factor in the dynamics of asset prices, not only in the short run but also over longer periods of time.

4. OTHER INFORMATIONAL INEFFICIENCIES

The EMH assumes that economic agents make correct inferences about an asset's intrinsic value by fully and accurately aggregating all relevant *private* and *public* information. In standard models, economic agents are usually assumed to observe *private* signals, (e.g. about prospects for the asset in question), as well as acting on publicly available information about observed market prices and volumes. In determining their investment decisions, individual investors rationally combine these sources of information, giving correct weight to the private and market information. These individual rational assessments take the form of orders to *buy* or *sell* the asset, which lead to movements in its price. Accordingly, through the collective action of rational individual traders, complete and proper aggregation of widely dispersed information occurs, resulting in an equilibrium market price which coincides with the asset's fundamental value.

The third broad strand of literature which challenges the EMH focuses explicitly on incomplete or imperfect aggregation of information as the main factor explaining deviations of observed asset prices from their intrinsic values. Participants in asset markets frequently ignore or neglect relevant information and focus instead on some piece of extraneous information or variable, the relevance of which is highly

tenuous. This can lead to substantial departures of asset prices from their intrinsic values.

Recent theoretical innovations on the microeconomic foundations of the trading process advance novel explanations for the presence informational inefficiencies in speculative asset markets. This literature, referred to as the *microstructure of financial markets*, provides a variety of plausible arguments as to why asset prices will not always fully and immediately reflect pertinent information available in a market. It also helps explain why asset prices can change sharply even without the arrival of new relevant information.

4.1 Asymmetric Information Models of the "Crash"

The distinctive feature of this literature is the explicit modelling of interactions between rational but *asymmetrically informed* traders.[27] It focuses on the structure of *information flows* between such market participants and examines how the actions, and expectations, of an individual investor are influenced by the perceived actions, and expectations, of other investors in the market. This structure has implications for the trading environment and for the size and speed with which pertinent new information affects asset prices. Models of this kind play a prominent role in recent theoretical analyses of financial panics, such as the stock market crash of 1987.

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[27] The theoretical literature on the problems posed by heterogeneous and asymmetric information in speculative asset markets has its genesis in the seminal contributions of Sanford Grossman. See in particular Grossman (1976, 1977, 1978, 1981) and Grossman and Stiglitz (1980).

One of the central propositions that emanated from these theoretical contributions is what is sometimes referred to as the "*paradox of fully revealing rational expectations equilibrium*". (A fully revealing rational expectations equilibrium is defined as being one where the equilibrium market price reveals and aggregates all diverse information). Grossman and Stiglitz (1980) demonstrated that the notion of market efficiency is incompatible with competitive equilibrium in the presence of information costs: with costly information there cannot exist a competitive equilibrium price which fully reflects all relevant information. The logic of the argument is relatively straightforward. If market prices were informationally efficient (i.e. they reflect and convey all relevant information available in an economy), there would not exist any incentives for economic agents to outlay the resources in acquiring and collecting new information; it could be costlessly obtained by observing the prevailing market price. However, if no individual economic agent has an incentive to collect and acquire new information, how does new information get aggregated or impounded into the market price in the first place?

Gennotte and Leland (1990) explain "crashes" in terms of the inability of investors to perfectly distinguish between "information-based" trades (i.e. transactions due to arrival of new information) and "informationless" transactions (i.e. those arising from dynamic hedging strategies such as portfolio insurance). A critical assumption underlying this analysis is that a large segment of market participants has no independent information about the outlook for an asset, and instead makes investment decisions based on their observations of the current price. Only a small proportion of investors ("informed investors") actually possess relevant private information about future economic fundamentals. With such a structure, Gennotte and Leland demonstrate that erroneous inferences made by the "uninformed" segment of the market, in the face of an unobserved supply shock, can lead to precipitous falls in asset prices that cannot be justified in terms of the fundamentals.

In this model, the following chain of events leads to a crash: some negative information enters the market, initially triggering a small fall in asset prices. This prompts sales by portfolio insurers, which magnify the initial fall in the asset price. "Uninformed investors", who do not know that the sell orders have come from execution of portfolio insurance programs, assume incorrectly that the significant price fall reflects actions of (better informed) investors acting on the receipt of new information. This causes the larger "uninformed" segment of the market also to sell, eventually prompting massive selling and a "crash" in asset prices.

Similarly, Grossman (1988) in a paper discussing the effects of program trading and dynamic hedging strategies on stock prices (presented at a conference four months before the Crash of 1987) prophetically warned of the possibility of financial crashes in speculative asset markets characterised by significant information asymmetries. He argued that heavy selling due to portfolio insurance, if the selling were erroneously interpreted by uninformed investors, would make the market highly vulnerable to a large fall in asset prices.[28]

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[28] Central to Grossman's argument is the important informational distinction between a *real security* and a *synthetic security* - a set of dynamic trading strategies which attempt to replicate the payoff profile of an actually traded security. "Portfolio insurance", a trading strategy in risk-free securities and index futures which replicate the payoff profile of a European Put Option, is an example of such a synthetic security. Grossman argues that even though dynamic trading strategies such as portfolio insurance can synthesise the payoff of a real security (a European put option), they impose quite different informational demands on actual market participants. Grossman argues that the price of a real security such as an option conveys

4.2 Role of the Trading Process

Examination of mechanisms by which asset prices move, in the absence of new information about fundamentals, is at the forefront of the latest theories on speculative markets. Contrary to the predictions of the EMH, this literature explicitly acknowledges that new information is not immediately reflected in asset prices and that trading activity itself plays an essential role in both the release and dissemination of privately held information. It demonstrates that even with totally rational economic agents, asset prices need not adjust instantaneously to new information. Nor will sharp asset price changes necessarily reflect the contemporaneous arrival of significant "news" on fundamentals. The relevant literature remains relatively fragmentary; the remainder of this section discusses some representative samples.

Bulow and Klemperer (1994) develop a model which shows how "frenzies" and "crashes" in asset prices can arise without the arrival of significant news about fundamentals. The starting point for their analysis is that, in reality, asset markets are not cleared by a Walrasian auctioneer who aggregates asset demand and supply before posting an equilibrium price. Rather, in speculative markets, investors make inferences about demand and supply by observing a sequence of actual transactions.

Such a trading structure encourages certain strategic behaviour by rational investors. Prospective buyers are confronted by the problem of determining the best time to purchase an asset: should they buy now at the current price or postpone their purchase to a later point in time in the hope that they can get a better price. The decision to purchase an asset hence depends not only on the buyers' reservation values, but more importantly on their expectations about future market-clearing prices. So there may exist a large number of buyers with very different reservation values for the asset, all having the same "willingness to pay".

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important information concerning future trading plans and price volatility which is not transmitted when investors utilise a dynamic trading strategy. The increasing substitution of synthetic securities for real securities therefore renders asset markets far more susceptible to erroneous assessments and inaccurate inferences.

This state of affairs can make market participants extremely sensitive to even the slightest piece of new information. Bulow and Klemperer demonstrate that mere observation of a purchase by a single buyer will be sufficient to generate a "frenzy" of buying activity: such marginal information is all that may be required to alter buyers' perceptions about the prevailing price from "slightly too high" to "sufficiently attractive". The resultant large increase in trading will reveal information about asset prices and either reinforce initial buying, possibly leading to a situation in which demand "feeds on itself", or to a "crash" where the asset price falls precipitously.

Romer (1993) contends that some changes in asset prices are quite rational even if they are not in response to "external news". This view is based on two propositions:

- new information about an asset's fundamental value is dispersed among a large number of investors and asset markets are unable, immediately and fully, to aggregate all of this information.
- the trading process itself can reveal pre-existing, but not yet fully "processed", information about fundamentals, especially investors' assessments about the relevance of new information for an asset's intrinsic value. Accordingly, Romer conjectures that an important part of actual movements in an asset's price can be explained by "internal news" generated by actual trade in the asset.

Romer advances two simple models to illustrate the general idea that the trading process can convey relevant information. These mechanisms are neither mutually exclusive nor exhaustive.

The first is a scenario in which information is *heterogeneous* and each investor is uncertain about the quality of information other investors have. Individual investors will learn from observing actual trading - say, the market response to a large transaction. This response to such a "non-informational" change conveys to individual investors information about market "sentiment", possibly leading to a re-weighting of the investor's own views about the asset's fundamental value. Such re-

assessments will result in discrete, and possibly substantial, movements in relevant asset prices.[29]

The second scenario involves information of *uniform quality*, which is *widely dispersed* among a large number of active investors in the market, and where there are costs to trading. Under these conditions, rational investors might not have sufficient incentive to trade immediately upon receipt of relevant new information. Such information might only gradually be incorporated in asset prices as trade (motivated by other considerations such as liquidity needs) is undertaken at a later point in time. Thus asset markets might initially fail to reveal all new information possessed by different investors in the market. Observed movements in asset prices, unrelated to the arrival of new information or "external news", are interpreted by Romer as reflecting the market's response to "internal news" - the continuing refinements of investors' assessments of previously released information relating to an asset's fundamentals.

In a similar vein, Caplin and Leahy (1992) develop a model in which they demonstrate that markets would be highly susceptible to crashes and collapses if the trading environment were characterised by widely-dispersed and idiosyncratic information and investors altered their behaviour infrequently. This model has two important assumptions:

- individual investors incur *fixed costs* when they change well established behavioural patterns; and
- individual investors' private information is conveyed to other market participants by alterations to their routine behaviour.

As a result of the fixed costs associated with changing routines, relevant information may be trapped "locally", to be released only when a large number of individual investors decide to alter their routine behaviour in response to a substantial change in economic fundamentals. "Routine" behaviour thus impedes the dissemination of relevant information held by individual investors and creates the potential for large

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[29] This first model of Romer's is not dissimilar to the arguments presented in Gennotte and Leland (1990). Romer actually advances this structure to explain episodes characterised by large asset price movements without the arrival of significant outside news (viz. the stock market crash of 1987).

swings in market sentiment when a sufficiently large number of investors decide to alter their "routines".

In Caplin and Leahy's model, only a small piece of additional information is required to precipitate a market crash or collapse. Such a small piece of additional news may be sufficient to cause an individual investor to alter his/her routine behaviour, releasing private, idiosyncratic information. This might prompt other investors and traders to do likewise. Through such a process, the market will observe rapid disclosure of a large body of previously accumulated and relevant - but previously "hidden" - information, which might lead to a radical change in market sentiment, and possibly a market collapse. In this framework, a market "crash" is viewed as a mechanism by which markets aggregate previously received, but widely dispersed, private information, rather than being the product of irrational behaviour. The "post-crash" market price is the one which would accord with all relevant information.

Dow and Gorton (1991) attempt to capture the notion that interpreting new information may be a complex task. They emphasise the idea that decisions based on an individual's private information may be fundamentally different from those that might be made if they were based on the aggregate of the new information received by all investors in the market. In these types of models, the trading process is a vehicle for releasing privately held, or hidden, information

4.3 Herding Behaviour and Informational Cascades

Herding behaviour - a situation in which investors ignore their own information and imitate the actions of other investors - has often been cited as one of the factors that can generate serious asset price inefficiencies and misbehaviour. The recent theoretical literature has also advanced new *rational* models of "herding" and "herd-like" phenomena .

Froot, Scharfstein and Stein (1992) examine the implications for speculative asset prices when rational investors and traders possess *short-term trading horizons*. In a simple theoretical model, the authors demonstrate that when speculative asset trading is dominated by short-term considerations, a particular type of informational inefficiency may arise: rational speculators may focus attention, or "herd", on certain types of information, while neglecting others. It may be rational for

speculators to trade on, and " choose to focus on very poor quality data, ... *even on completely extraneous variables* that bear no relation at all to fundamentals".[30]

These results are driven by *positive informational spillovers* - as the focus on a particular variable becomes increasingly widespread, it is more likely to be incorporated into the actual asset price. As a result, there are strong incentives to study this information at the expense of other variables, including information which may be far more relevant to determining the asset's fundamental value. A type of positive feedback therefore operates in the process of acquiring information - the greater the attention paid to a particular variable, the more valuable new information about that variable becomes, and so the focus on it will intensify and news about it will become more valuable still.

To illustrate, suppose that there are two variables, *a* and *z*. In a model in which trading horizons are short term, if a critical mass of market participants was to focus on variable *a*, the positive informational externality would result in a herding equilibrium in which everyone in the market would study only information about *a* and base trading activity on it. Information about *z* would be completely ignored, even though *z* might be particularly important to the performance of the asset concerned over the longer-run. Froot *et al.* note that this is one rationale for "chartism" and technical analysis in asset markets: "... *the very fact that a large number of traders use chartist models may be enough to generate positive profits for those traders who already know how to chart. Even stronger, when such methods are popular, it is optimal for speculators to choose to chart. ... Such an equilibrium can persist even if chartist methods contain no relevant long-term information."*[31]

Froot *et al.* also demonstrate that such herding equilibria do not imply that the market participants will always focus on the same variable. The structure can accommodate a situation in which market participants show intense interest in one variable for a short period of time (say, the current account), and then switch their attention to something else (e.g. monthly employment statistics).

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[30] Froot, Scharfstein and Stein (1992, p. 1463).

[31] Froot, Scharfstein and Stein (1992, p. 1480).

In this framework, asset prices depart from fundamentals not because of a malfunction at the *pricing* stage of the market process, but because of imperfections emanating at the *information acquisition* stage. In other words, asset prices will immediately and fully reflect information, once a given set of information has been acquired. Inefficiencies arise, however, when the information set is not "relevant" (i.e. it is not related to economic fundamentals) or is incomplete.

A principal contribution of Froot *et al.* is that they develop a "microstructure" for the speculative bubble process. By providing a theoretical explanation as to why rational investors and traders might focus on totally extraneous information, the authors describe one mechanism by which bubbles and bubble-like episodes of financial instability might emerge and be propagated.

Another innovative contribution to this literature is offered by Bikhchandani, Hirshleifer and Welch (1992).[32] Bikhchandani *et al.*'s contribution involves a theory of "*informational cascades*"[33] which explains why behaviour converges, how this situation is maintained, and why it can be fragile (in the sense that small shocks can lead to dramatic changes in behaviour).

An *informational cascade* occurs where it is optimal for individuals, after observing the actions of previous agents, to ignore their own information and mimic the decisions of their predecessors. Informational cascades therefore tend to produce uniform actions by a large number of rational economic agents, who may possess disparate and conflicting private information. They are likely to be most evident in a *sequential* trading environment in which individuals have *limited private information*. This class of model shows that, when individuals base their decisions on private information and observations of their predecessors' behaviour, informational cascades develop with virtual certainty.

Bikhchandani *et al.* emphasise that the decision to ignore private information and participate in the "herd" arises from a process of rational decision making. It should not necessarily be interpreted as representing irrational or foolish behaviour. The actions of predecessors provide valuable information, since this history reveals

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[32] See also Hirshleifer (1994).

[33] The notion of an "informational cascade" was first formalised by Welch (1992) in his theoretical discussion on the optimal pricing of Initial Public Offerings (IPO).

information about *private signals* that other agents have received. A rational decision maker will, therefore, combine this evidence with his private information. If he observes other investors repeating a particular action, it is rational to conclude that these investors have all received the same signal. Accordingly, he will give added weight to the implications of his predecessors' actions, even if his own information has a contrary implication. Once the information implicit in the actions of other investors accumulates to the point where it *marginally* outweighs his own information, the optimal response is to imitate unconditionally the actions of other investors. The next individual will then find that the accumulated evidence from his predecessors actions begins to dominate his information, and find it optimal to join the cascade. Such a chain of reasoning extends to all subsequent individuals and the cascade takes hold.

One feature of Bikhchandani *et al.*'s approach, is that informational cascades are inherently fragile.[34] Since they can develop on the basis of very little information, and their "depth" does not increase with the number of individuals in the cascade, informational cascades can also collapse suddenly with the arrival of a small item of news. This "knife-edge" property arises because uniformity of actions occur when everyone in the cascade just barely prefers to ignore their own information and imitate the actions of others. This makes the cascade brittle.

Informational cascades hinder the proper aggregation of widely dispersed relevant information since, once a cascade develops, actions of successive individuals do not reflect relevant information which they have received; by definition, individuals become part of a cascade when it is *optimal* for them to *ignore their own private information* and follow the actions of others. As a result, informational cascades

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[34] Birckhcandani, Hirshleifer and Welch (1992) identify four other mechanisms/theories of conformity that have appeared in the recent literature. These are (i) *sanctions against deviants;* (ii) *positive payoff externalities;* (iii) *conformity preference*; and (iv) *communication*. The authors point out that these processes, unlike informational cascades, induce patterns of mass conformity which are resilient to small shocks or perturbations. The fragility of an informational cascade is what distinguishes it from these other models of mass conformity.

may lead to outcomes which are sub-optimal or inefficient, given all the relevant information.[35]

4.4 Rational Beliefs

The final seminal contribution to be discussed is by Kurz (1992). He develops a model in which asset mispricing arises from the heterogeneous beliefs of rational economic agents, reacting to the same piece of information. Kurz introduces the notion of *rational beliefs* which are defined as "probability beliefs about future economic variables which cannot be contradicted by the data generated by the economy". He argues that the set of such rational beliefs will generally be very large and their diversity is the most important cause of serious overvaluations (and undervaluations) in asset prices. The view that even rational economic agents do not and cannot possess complete "structural" knowledge of a dynamically evolving economic system underlies Kurz's analysis; as he states *"... the assumption that agents possess complete structural knowledge has no empirical support ... there is much in the dynamic structure of the economy which cannot be learned with certainty."*[36] Consequently, it is possible that two rational economic agents who receive the same piece of information, will hold totally different views about its likely impact on asset prices.

Kurz's framework explicitly allows for the possibility of inaccurate assessments of available information by rational economic agents individually, as well as by the market as a whole. In this model, the source of asset price inefficiencies does not lie in imperfect aggregation of relevant information, but in the unavoidably imperfect evaluation of already processed information by rational economic agents.[37]

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[35] See also Banerjee (1992), Kirman (1993) and Lee (1993a,b) for further contributions to this literature.

[36] Kurz (1992, p. 1).

[37] Some further theoretical contributions which have not been discussed but are worth drawing attention to are: Allen and Gorton (1993), Banerjee (1993), Friedman and Aoki (1992), Topol (1991), Wang (1993) and Ziera (1993).

5. CONCLUSION

A decade ago the Efficient Markets Hypothesis occupied a position of overwhelming dominance in the academic community. Speculative asset markets, including foreign currency markets, were viewed as being informationally efficient, with the conduct of rational investors and speculators ensuring that significant and sustained departures of asset prices from their fundamental values would not occur. The widespread intellectual allegiance accorded to the Efficient Markets paradigm no longer prevails. Its stature as the predominant model of asset market behaviour has been eroded not only by the actual behaviour of asset prices - including exchange rates in recent times - but also by the emergence of rigorous and cogent theoretical arguments challenging its central propositions. As a result, the academic community has undertaken a fundamental re-assessment of previously held views concerning not only the determinants of asset price movements, but also of the merits of certain policy instruments employed by governments and central monetary authorities.[38]

This paper has summarised some of the key propositions and arguments underlying an influential and rapidly growing body of new theoretical literature on asset price formation. The dynamics of the price formation process in speculative asset markets has always attracted considerable interest from academic economists. In recent years it has been an area of very active research, both theoretical as well as empirical; undoubtedly it will continue to be so in the years ahead as the profession refines and enhances its understanding of the dynamics of asset price formation.

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[38] *Sterilised foreign exchange intervention* is an example. Until recently, the view that there is a positive role for sterilised foreign exchange intervention did not have much support among academic economists, primarily due to their intellectual allegiance to the EMH, and in particular to Friedman's (1953) arguments concerning the stabilising influence of rational speculators. The theoretical literature surveyed in this paper however, demonstrates not only how and why an asset price such as the exchange rate, can deviate substantially from its "fundamental" value, but also sheds light on the circumstances and conditions in which official intervention in the foreign exchange market might be effective. A sample of theoretical contributions which advance a positive role for sterilised foreign exchange intervention are: De Long, Shliefer, Summers and Waldman (1990a), Dominguez and Frankel (1993), Hung (1991a, 1991b), Krugman (1989a, 1989b, 1991), Krugman and Miller (1992), and Miller, Weller and Williamson (1989). For discussion on the motivations underlying the Reserve Bank of Australia's intervention operations in recent years, see Macfarlane (1993).

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