

Decision-rule cascades and the dynamics of speculative bubbles

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Abstract

We combine Minsky's financial fragility analysis, behavioural analysis of decision rules and the evolutionary economics of rule trajectories to provide an empirically grounded and computationally tractable theory of the complex evolutionary dynamics of speculative financial upswings. The behavioural dynamics of asset bubbles can be conceptualized as the joint consequence of the adoption and diffusion process of new investment decision rules coupled with the degradation of those rules as they pass from a few expert investors to larger population of amateurs. We illustrate this using data covering the recent Brisbane property market bubble (1999–2003) and show how it is consistent with the existence of such cascading decision rules. We then explain how multi-agent simulation methods can be used for modelling decision rule cascades.

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1. Introduction

Macroeconomic theory has plausible and straightforward explanations both for asset price movements that take the form of small, rapid, step-like adjustments to changes in the

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‘state of the news’, and for precipitous leaps or crashes in asset prices. The former are readily explained in terms of the ‘efficient markets hypothesis’ and ‘rational expectations hypothesis’. These presume that decision makers rapidly acquire the same set of relevant information for appraising potential asset yields and are not prone to be systematically wrong in the appraisals they make.

New information – for example, the release of new economic statistics, or regarding a political event, discovery of new deposits of a natural resource, or an unexpected invention – will only temporarily cause trading and asset price movements, for soon it will become widely known and the vector of relative prices of assets will settle at a new configuration whereupon assets offer identical risk and carrying cost-adjusted yields. This analysis rings true on days when it is reported that, say, the release of a country’s balance of payments figures had no impact on the value of its currency because they were ‘what the market expected’, or when there was an instantaneous adjustments up or down in the value of the currency because they were better or worse than expected.

The possibility of precipitous price movements is emphasized in Keynes’s (1936) work as something that arises if decision makers start holding similar expectations about prices. Keynes’s (1936) discussion of the determination of interest rates portrays the orderly functioning of asset markets as requiring differences in the expectations held by wealth holders. People who are holding cash and foregoing the interest they might have earned by holding bonds are doing so because they fear bond prices will fall and give them a capital loss that is not offset by the interest yield – a view that is evidently not shared by those who are holding bonds rather than cash. If everyone believed bond prices were going to fall, no one would be willing to hold bonds and their prices would collapse as bond owners sought to sell them and found no buyers. This convergence-driven instability is pretty much the kind of thing that happens in episodes of hyperinflation (when it is clear that money is an asset that no one in their right mind should hold) or in a share market crash.

The intermediate case, of asset price movements that are ongoing over periods of months or years, is more complex to analyse and the present paper is offered as a contribution in this area. We suggest that phenomena such as the emergence of a boom in the market for residential investment properties involve something rather more complex than merely a succession of adjustments to a flow of new *information* about the performance of real estate investments relative to other assets.

Like Minsky (1975), we take the view that as booms gather pace people change their *investment strategies* and start taking risks they previously were not taking. In this sort of context, Keynes’s emphasis on differences between speculators’ views of market prospects seems a better starting point than the mainstream rational expectations view. An obvious next step is to imagine an increasing convergence of how speculators see investment prospects. This leads to two questions: the first is how such a process might occur; the second is whether such a process is inherently prone to lead to a kind of collectively irrational expectation about the returns their investments might deliver, ultimately leading to a precipitous market correction.

In exploring the forces underlying the dynamics of speculative episodes we apply and extend several ideas from behavioural and evolutionary economics regarding the nature of decision-making processes (Earl, 1986; Earl & Potts, 2004). These lead us to posit that a ‘decision rule cascade’ is a particular form of what Dopfer, Foster, and Potts (2004) and Dopfer and Potts (forthcoming) call a ‘meso trajectory’. But whereas most meso trajectories increase the value and complexity of a rule at the same time, a decision rule cascade is

degenerative in that an increasingly simplified rule replicates. Decision rule cascades amongst the population of wealth holders may therefore drive speculative episodes, but the way such a cascade works does not tend to result in everyone trying to follow the same speculative decision rule. Specifically, we posit that complex and subtle expert decision rules experience a kind of entropic degradation as they are sequentially adopted by a growing population of amateur speculators.

The paper is divided into four sections and a conclusion. First, we introduce the decision rule cascade idea and contrast it with the now well-established information cascade notion. Secondly, we consider how decision rules may suffer degradation as they are passed from agent to agent along a spectrum from expert to amateur speculators. Thirdly, we examine how a cascade of partially degrading decision rules may generate a boom in a market during which some players will tend to fare far better than others and, fourthly, we suggest how this may be modelled.

2. Decision rule cascades versus information cascades

Until fairly recently, an emphasis on the role of crowd behaviour in shaping the way the macroeconomy functions was confined to a small group of economists that [Coddington \(1976\)](#) labelled as ‘fundamentalist Keynesians’. Members of this group emphasized tendencies for investors to take cues from each other about possible changes in market conditions and that success in investment decisions requires an ability to anticipate how ‘the market’ thinks and how it will respond to particular changes in the ‘state of the news’. On this view, asset markets could be prone to suffer from collective mood swings and become increasingly jittery when a boom has been strong. This is because speculators will be conscious of the need to be amongst the first to sell assets if they are to realize maximum capital gains when the market reaches a turning point. A discontinuous shift from boom to crash may thus come from some investors crossing a psychological threshold in terms of nervousness about the sustainability of the existing price structure, rather than from any particular objective threshold having been crossed ([Minsky, 1975](#); [Shackle, 1974](#)).

In contrast to the network-based view of choice in the fundamentalist Keynesian literature, the traditional mainstream approach was to model investment choices in a reductionist manner as if they were being made by well-informed representative agents whose preferences represented a microcosm of stable, aggregated preferences of all the individuals who form the economy as a whole. It is difficult to explain the existence of speculative bubbles from this perspective and the literature has sought to resolve this in several broad directions (see [Raines & Leathers, 2000](#)). One approach is the behavioural finance literature (e.g. [Shiller, 2000](#)), which introduces systematic biases in risk preference, framing effects and suchlike in order to explain systematic departures from rational behaviour. Another approach is to focus on the sequence of information transmission itself in a speculative market. Theoretical work on information cascades by writers such as [Diamond and Dybvig \(1983\)](#), [Bannerjee \(1992\)](#) and [Bikhchandani, Hirshleifer, and Welch \(1992\)](#) considers how markets function when it takes time for information relevant to choices to spread between decision makers. In this kind of work, unlike that of the fundamentalist Keynesians, decisions are still firmly anchored in given preferences, but people may make their choices at different times depending on when they receive information that removes the uncertainty that is otherwise inhibiting investment.

De Vany's (2004) book *Hollywood Economics* provides an excellent example of a market in which information cascades are a major driving force for the volume of sales. (In this context, price has little role to play since cinemas normally operate with fixed price and charge the same price to a customer regardless of which movie they wish to see.) A movie is an example of an 'experience good' (cf. Nelson, 1970): one cannot know for sure whether it is worth consuming until one has consumed it. Unless one has access to reviews by film critics or has heard reports from friends and/or acquaintances, it is very hard to know in advance whether a particular film is going to be worth watching. Hence demand is crucially dependent on the spread of published and word-of-mouth reports. The thing to notice here is that the reports serve to resolve uncertainty about a film's characteristics – the quality of the acting, the plot, whether it is far too long and loses the audience's interest, and so on – that you are likely to experience if you go to see it. Social network effects of this kind have much the same role to play with regard to the diffusion of innovations, where there is initial uncertainty about whether they are worth adopting.

In the context of decision-making in speculative markets such as those for shares and investment properties, however, the information cascade idea has a rather secondary role to play. For one thing, the proposition of efficient markets theorists, that all relevant information is rapidly transmitted to all market participants, may here be quite a reasonable approximation as the financial press and websites make information widely available within minutes or hours of its release and, moreover, automated trading strategies can process that information and execute trades within seconds. Yet despite this, booms in share and property markets take time to gather pace. Secondly, and more importantly, the information that is available relates to *past* performances of particular assets, or to factors that *might* affect their future performances, but it is not information about what the relative future performances of rival assets *will* be. Its significance depends on its *interpretation*.

The interpretation issue is missing from areas to which the information cascade idea had been applied. For example, information about a new movie's characteristics tells us whether we will like it if we have preferences for particular kinds of movies; in mainstream analyses, these preferences are taken as given. By contrast, the significance of socially transmitted information about the state of the property market, or about what others have experienced (say, in terms of vacancy rates and maintenance costs of investment apartments that friends have purchased) depends upon what *decision rules* we have for appraising investment possibilities and/or the kinds of rules we have for learning – that is to say, our rules for adjusting our investment rules.

Another way of putting this is in the terms proposed by Ryle (1949): information about market indicators is of the 'know that' variety, but for it to be of any use requires relevant expertise/an appropriate capability – in other words, it requires 'know how'. Whereas rational expectations theorists presume that decision-makers interpret information in terms of mainstream economic models on the basis of an inductive learning process (see the critique by Boland, 1986), we suggest that it may be fruitful to think of decision makers in highly uncertain speculative markets as using (variants of) decision rules that they have picked up from others as their means of interpreting and acting upon information and, indeed, for selecting which kinds of information to gather.

This perspective is entirely consistent with the Keynesian position, and indeed Keynes (1937) himself made a number of suggestions about broad kinds of rules that people use for coping with non-probabilistic uncertainty, such as following the majority in the belief that other people are better informed than we are. Where our perspective is novel is in its

emphasis on how rules may be quite complex and get transformed as they get transmitted from person to person and because it entails a multi-level view of decision rules: a decision maker may encounter many potentially useful rules for making investment decisions in the course of social life, and hence needs higher-level rules for choosing between them. For example, one might use information about the credentials and/or personal wealth of a person who was advocating a particular investment rule as a basis for deciding whether their strategy is worth adopting.

Decision rules play a central role in behavioural and evolutionary economics (see e.g. Dopfer et al., 2004; Earl, 2001; Hodgson, Samuels, & Tool, 1994; Witt, 2003) as tools for coping with uncertainty and complexity, with rules that perform poorly in a particular context being prone to be de-selected in favour of those that appear to be delivering better outcomes (or agents who fail to change dysfunctional rules being de-selected as market players due to, say, bankruptcy). If we possess efficacious decision rules, our need for certain kinds of information or for social networks for obtaining information may be reduced. In the case of the demand for movies, a rule that says ‘a film that is directed by and/or stars particular people, whom we rate highly on the basis of their previous work, cannot be terrible, for they would not risk their reputations on an inherently bad project’ obviates the need to find out what others have made of it. Knowing that a particular critic has given it a four-star rating may be sufficient as a basis for choice even if we know nothing about its plot, if our rule is ‘only watch four- or five-star movies’. Likewise, if our preferred rule for investing is ‘do what Warren Buffett does’, then all we need to know is what investments Warren Buffett is making, while if our rule is ‘only invest in residential property’, we greatly reduce the set of information we need. In each case, the decision rule comes prior to the information gathering.

What we are suggesting about the social origins of many people’s investment decision rules is an extension of thinking in a recent paper in which Earl and Potts (2004) use the decision rule perspective to look at the origins of preferences in today’s complex and rapidly changing world. The suggestion there is that economic agents trade decision rules with each other socially, after specialising in developing expertise in particular product areas. Consumers are presumed to have well defined high-level preferences, but to need to acquire capabilities regarding what to do in order to act upon such preferences. Those with relevant expertise supply them with rules that have the form ‘if X is what you are trying to achieve, then Y is a good means of achieving it’. The ‘market for preferences’ entails such rules being supplied both by professionals (such as sales personnel, consumer journalists or specialist consultants such as interior designers) and by members of their social networks, or friends of friends, known for their expertise.

Our contention is that much the same process applies in speculative markets: decision rules cascade from person to person, springing initially from those who appear to know what they are doing in the context in question. Property speculators, for example, may spread their wisdom by writing books on ‘how to make your fortune in real estate’, by running pay-to-attend investment seminars, or through exchanging their ideas socially, for example, with their accountants, dentists, Rotary club and Masonic colleagues, at dinner parties, and so on. In turn, others will copy those who pick up the ideas and who appear to be prospering by applying them. Thus the property speculators’ dentists’ assistants start to seek ways of getting investment properties of their own, and are then copied by their friends, who in turn become role models for yet other members of their social networks. As they choose particular kinds of decision rules, investors may seek to refine them by

studying what others with expertise in the same area are advocating. For example, having decided to concentrate on residential property investments, a person may seek out books by pundits in this area and study the views of real estate professional as reported in the financial press, and so on. In turn, others may pick up the rules that they synthesize and make further modifications.

In common with many social networks, the network by which decision rules spread will not be a random one; rather, as our references to the role of noted pundits and specialized publications imply, it will be more in the form of a 'scale-free' network in which some nodes are highly connected hubs but most are rather weakly connected (for a thorough and useful review of the networks literature, see [Dorogovtsev & Mendes, 2003](#)). The decision rule cascade process shares this network property with information cascades such as those where movie critics' rating have a major role in shaping how well movies fare at the box office. However, in contrast to the spread of information in today's information technology-rich world, the cascading of decision rules is a process that inherently takes non-trivial amounts of time. In the case of property speculation, it takes time to raise finance and find suitable properties and for paper profits to become evident if the market does indeed rise, and those who attempt to copy such strategies will likewise take time to implement them.

3. The process of rule degradation

Lags in the social transmission of decision rules are likely to mean that those who acquire them far down the cascade will be employing rules that fit the changing environment far less well than they did at the time they were applied by those that originated them. For investment strategies to match a changing environment, they may need to be in the form of systems of rules that specify how strategies should be adjusted as an investment cycle unfolds. If so, what needs to be transmitted from one decision maker to another is going to be quite complex. Even if the decision environment is static, the rules for making the most of it may comprise systems of interlinked 'if-then' requirements.

Where decision rules are complex, a decision rule cascade seems likely to operate rather like the schoolyard game known as 'the telephone game' or 'Chinese whispers', in which players arrange themselves in a circle and whisper in the ear of the player on one side of them the message they think they have had whispered in their own ear by the player on their other side. By the time the message is relayed back to the person who initiated it, the wording has typically changed greatly. In the context of messages about investment strategies, what we suggest is likely to happen is not necessarily that the message is completely lost or turned around but that details and qualifications are lost as it is passed from person to person. In the case of dot-com stock investment rules, for example, early 1990s expert venture capitalists had rules about specifically which management and talent teams went with which new business models under which financial plans, and under which customer profiles; by the late 1990s, the idea that there might be money to be made from such investments had achieved much wider currency but at the cost of degenerating into a simple rule of buying any stock ending in dot-com. Much the same thing happened with electronics in the 1960s and radio in the 1930s and at many other times both between and before (see [Chancellor, 1999](#)).

As far as property investments are concerned, there is a world of difference between basing purchases around a simple 'location, location, location' decision rule that operates with

reference to a list of suburbs widely known to be ‘desirable’, and having at one’s disposal the result of a hedonic pricing model that pinpoints precisely how much particular location-related characteristics such as distance from the CBD add to median property values. Likewise, an expert speculator in investment property might be using an investment decision rule that says ‘buy un-renovated two-bedroom apartments within two miles of the CBD or university, that are between five and 20 years old, within two minutes’ walk from public transport routes, and with afternoon sun, and then renovate them only by ... and then realize capital gains by selling them when ...’. By the time the message has been transmitted many stages down the cascade, it might simply read ‘invest in rental apartments in the city and wait’.

We are not trying to suggest that the spread of a decision rule necessarily results in the generation of variants that are inferior to the original. To make such a suggestion would be to ignore lessons from business history, which is littered with examples of cases where firms that pioneered particular strategies for success failed to capture substantial rents because, whilst their broad intuition was correct, the way that they executed it was flawed, and others who observed what they were doing were able to infer much better ways of making it reliable, practical or included whatever else turned out to be key features required by customers (for example, contrast the original De Havilland Comet jet airliner and the Boeing 707, or the original 12-inch Philips Laservision disc technology versus the DVD). Within a population of investors we would not be surprised to find a proportion of astute decision makers who might accept a highly simplified basic proposition such as ‘to make money, invest in rental apartments’ but who also possessed higher-level rules that (a) led them to judge that they lacked experience of investing in this market and (b) required them address this deficiency by taking time to acquire or synthesize a more refined version of the rule before they invested. (Dopfer & Potts (forthcoming) call these second-order rules, i.e. rules about how to choose rules, and argue that they are essential to the process of economic evolution.) Other decision-makers, however, might lack rules for going about refining a simplified rule, and hence end up making decisions that proved to be expensive mistakes – for example, because they lacked expertise for judging older apartments and getting makeovers done in a cost-effective manner. They might provide ready fodder for property developers that were selling ‘off the plan’, where scope for capital gains might be smaller and where carrying costs in terms of body corporate fees eat more heavily into current cash flows.

Degradation of decision rules will result from opportunism (in the sense of Williamson, 1975) and tacit knowledge (Polanyi, 1958). The opportunistic purveyor of decision rules may have good reason in terms of self-interest for suggesting rules that are somewhat different from what he or she has actually be using, or simpler in form. It may take less effort to convey such rules and/or their use by others could generate demand for assets that he or she presently owns, or a partial revelation of the rules may help the supposed expert to stay one step ahead of the market and thus make more money. Where tacit knowledge problems arise, the issue is not that a rule system is deliberately misrepresented but rather that the supplier is unable to articulate it in full detail or in a way that ensures it will be understood and capable of being applied in an identical manner by the recipient. Tacit knowledge is problematic even with something as seemingly simple as a basic cookery task: recipe books can differ quite markedly as they try to explain the ‘knack’ of, say, separating an egg white from its yolk (for examples, see Earl & Wakeley, 2005, Section 5.4). The problem of supplying capabilities for coping with speculative markets is exactly the same, in

principle, as that entailed in technology transfer arrangements (Nelson & Winter, 1982) or when students try to obtain knowledge by listening to a teacher or reading a textbook: even if a thorough description is supplied, there is no guarantee that a boundedly rational recipient will ‘get it’ or ‘pick it up’ in its entirety.

Decision makers are likely periodically to be ‘in the market’ for new investment decision rules produced by ‘experts’ owing to disappointment with the outcomes they have been achieving by applying particular rule systems. There will thus be a latent market for new rules and/or churning in the use of existing rules: as is evident from the market for books by business gurus, there is a fashion/fad element in the demand for strategies for making money in a changing, uncertain world. It will not merely be users of simplistic decision rules (such as the indiscriminate ‘invest in rental apartments’ rule) that are likely to be disappointed and open to new ways of investing. Many of the rule systems that people end up using will be at odds with rules based on an acceptance of the unpredictability of financial markets. Whereas the latter rules promote investing in passive unit trusts based on the market index, and diversifying portfolios across classes of assets, people who are reluctant to accept the unpredictability of markets and to base investment strategies on that unpredictability will be susceptible to systems based on trying consistently to achieve better returns than the market as a whole (for example, by using complex decision rules that focus on property investment). They will be attracted by systems that seem to be making others wealthy, even though such people have merely been lucky temporarily to be able to achieve above-average returns. As a result, they might, for example, switch from property investment to putting a disproportionate part of their wealth into ostrich farming or dot-com stocks.

4. Significance of decision rule cascades in speculative cycles

The consequences of having one’s investment decision rule (approximately) copied differ sharply depending on whether the investment involves the expansion of productive capacity or the purchase of existing assets whose supply is difficult to augment. In the former case, emulation of one’s choice will reduce the yield of the investment by depressing market prices (except in cases where demand is a positive function of the number of suppliers, because a greater visibility of the product generates interest in it). Going public with one’s investment philosophy regarding capacity expansion choices only makes sense if one is aware that others might independently reach similar conclusions and is seeking to preempt any bids they might make to win sales in that market (cf. Porter, 1980, pp. 335–338). Where assets are difficult to reproduce rapidly, the decision rule may be self-fulfilling as the prices of the assets will increase, giving capital gains to early movers into the market. Here, it is not just the pioneers of the decision rule who stand to make money from sharing it with others but also the media, such as newspapers and magazines that report the supposed wisdom of the pioneers. For example, by running prominent real estate sections, newspapers may generate substantial revenue from real estate advertising as people seek to relocate to areas that are reported as having more potential for capital gains.

A crucial point to note when considering how a decision rule cascade affects the operations of a market such as real estate, where the stock of existing assets is large relative to the flow of new output, is that one investor can only buy into it if another is selling out. To a certain extent, stock becomes available for reasons that have nothing to do with speculation, such as changes of domestic circumstances (in the case of real estate: children leaving

the family home, marital break-ups, retirement, death or job relocations). Otherwise, however, the lag in a decision rule cascade is necessary for the pioneer to be able to buy into the market at a price that will soon appear to have been a bargain. If experienced property speculators judge that bigger potential gains can be had by, say, selling out of inner city apartments and buying into an as yet under-developed beachfront suburb, their biggest chance of making an easy sale and a bargain buy comes if owners of properties in the beachfront suburb are laggards in adopting the ‘inner city apartments’ decision rule. The savvy decision rule pioneers might subsequently spot potential for greater capital gains in apartments near a local university, selling their beachfront properties for top-dollar prices to investors who are selling their inner city apartments to even later adopters of the ‘inner city apartment’ rule, who in turn are selling their apartments near the university in order to buy in to what they believe (mistakenly, in the eyes of the savvy players) to be bigger prospects of capital gains.

Clearly, the way we have just aligned a sequence of overlapping property market decision rule cascades with chains of transactions in investment properties is rather fanciful. However, it at least signals that if the same investors were, respectively, at the front and the end of each decision rule cascade, great inequalities in investment returns would be expected, as is evident in practice. In an actual property boom, to judge from Peng’s (2004) detailed study of the geography of capital gains in the Brisbane property market during 1998–2003, property prices move unevenly through time across different suburbs. There are neither roughly uniform rises that one might expect from population growth, nor systematically higher increases towards the city centre and along major transport arteries as a reflection of changing transport costs as the city spreads further and further. Rather, one may see a combination of sustained above average price growth for certain kinds of properties of inherently limited supply (at or close to the beach or river waterfront) and temporary ‘hot spots’ scattered around the wider city, that offer even more spectacular gains for those who spot them at an early stage. In other words, the situation is rather reminiscent of a share market with ‘blue chip’ stocks and previously neglected stocks in which interest flares up briefly.

The existence of temporary hot spots is readily understandable when there is a combination of a large geographical area with a hundred or more suburbs, and boundedly rational investors unable to keep in mind what is happening in more than a fraction of them at a time. In such a situation, more alert investors may notice that some suburbs are undervalued and, in buying up what is on offer, generate price increases that stand out enough to capture wider attention. No single decision rule would stand out as obvious to adopt and adhere to in such an environment, so it would not be surprising to find a number of decision rule cascades in operation, with investors switching in different ways as a property boom progressed and with the ‘flavour of the month’ in terms of a shrewd purchase.

Casual observation suggests an inverse relationship between the rate of increase of prices and the average time that properties are on the market, except where sellers start getting *really* greedy and have more trouble finding buyers. This is borne out in Peng’s study, from which Fig. 1 has been adapted, and in the context of the UK housing market recent work by Baddeley (2005) also reveals periodic explosions in the volume of transactions. (Baddeley’s work in many ways complements the present paper, except that her analysis of herding is in terms of cascades of information, not decision rules.) The emergence of such buying frenzies, in which demand increases for a time even though effective rates of return in terms of income flows are falling, is hard to fathom in terms of a view of rational investors making choices based on market ‘fundamentals’ but it is compatible with the decision

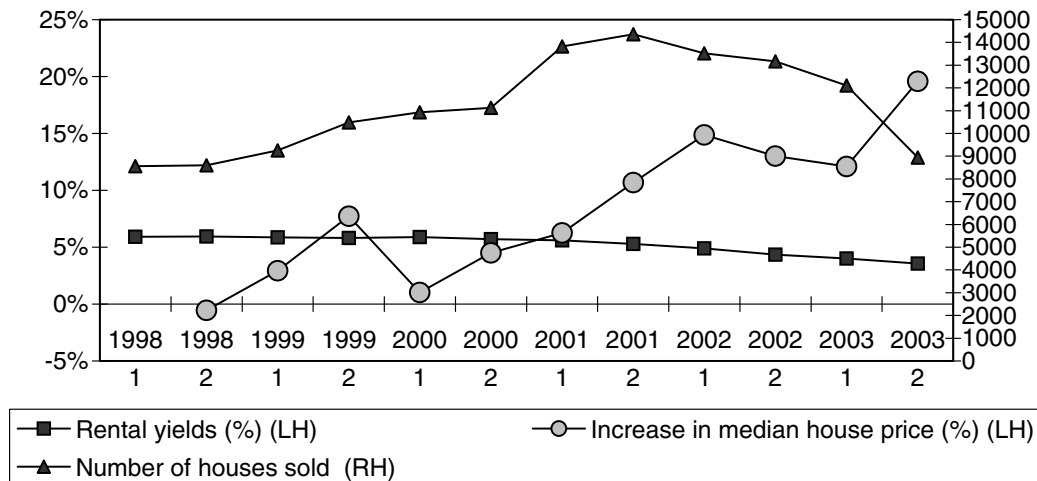


Fig. 1. The relationship between rental yields, increases in median house prices and the number of house sales in Brisbane, Australia, 1998–2003. As the growth of house prices accelerated from 2000 to 2002 the number of house sales continued to rise even though mortgage interest rates remained steady (not shown) and rental yields fell. (Includes data prepared by PRD Nationwide. *Source*: RP Data. Rental yields are for three-bedroomed houses and were calculated from weekly data from The Residential Tenancies Authority at <http://www.rta.qld.gov.au>.)

rule cascade notion. As with a contagious disease, the more people who seem to be using a decision rule, the more people will adopt it and so, because of that, the more the decision rule will appear to be delivering its expected results. Under these circumstances of positive feedback, the more it will appeal to inexperienced investors, even though they might do better to consider whether continued capital gains really are likely if rental yields are falling further and further behind financing and other carrying costs. Meanwhile, the early investors may judge that if they sell up and cash in their profits, they will now be able to make down-payments on (even more) properties in other suburbs that their more sophisticated versions of the ‘invest in property’ decision rule have led them to identify as ripe for even greater future gains.

From this perspective, the ability of experts with more complex versions of a particular investment decision rule to keep finding new ways of making above-normal returns is a crucial ingredient in keeping alive a boom in the broader market that is favoured by simplified versions of this rule. Questions are less likely to be raised about a simple ‘property is the thing in which to invest’ rule if some kinds of property investments are doing very well, even though the failure of many property investments to generate positive cash flows ought to be raising doubts about scope for them to deliver capital gains. When the market appears to have run out of steam in all areas, such illusions and their accompanying decision rules will be abandoned, and the speculative bubble will burst. As it does so, latecomer amateurs will suffer a disproportionate part of the losses. We have told this story in terms of speculative upswings in the housing market, but the principle generalizes to all classes of financial assets and over all market domains.

5. Modelling decision rule cascades

If the dynamics that we have suggested can be modelled, they may offer a fresh means for predicting or anticipating the emergence of aggregate coherent behaviour, that is

complementary to those explored by Sornette (2003, especially Chapters 4 and 6), with the aid of network theories, to analyse stock market crashes. (For a wider analysis of how individual actions involving combinations of imitation and idiosyncratic behaviour can result in critical events emerging at the aggregate level, see also Sornette, 2004.)

An obvious way to model the concept of a rule cascade as central to the formation of a speculative bubble is via agent-based modelling in an evolutionary computational framework. The analytic framework of micro meso macro (Dopfer et al., 2004; Dopfer & Potts, forthcoming) is based on conceptualising economic evolution as a process of ongoing *rule trajectories* in which new rules (that specify behaviours, technologies, institutions, organizational forms, etc.) are originated, adopted and diffused through the population of economic agents, so leading to a irreversible process of re-coordination of the connective structure of the macroeconomic system. In this view, an economic system is made of generic or meso rules, each with a population of carriers (agents) and specific connections to other rules. Structural change is a consequence of a new meso rule, and the origination, adoption and retention of a new rule permanently changes the coordination structure of the economic system.

A novel investment decision rule is precisely such a generic rule, and the implication is that we may model the dynamics of a new investment rule in exactly the same way that we would model the adoption and diffusion of a new technology. This is easily set up in an agent-based modelling framework where heterogeneous agents possess variant investment rules and (stochastic) probabilities of adopting the rules of a neighbour, wherein the specific structure of the network, e.g. random, Moore, small-world, would be expected to have significant effect on the extent and path of the decision rule cascade. Market dynamics can then be simulated to examine the effect of the introduction and adoption–diffusion of novel generic rules on price and asset/wealth allocation outcomes, under differing parametric settings (as in, for example, Morrison, 2004).

There is, however, one major difference between modelling the diffusion of technologies and the diffusion of rules for making investment decisions. In the former case, increasing involvement of less sophisticated market participants tends to be a good thing, as when it leads to producer/consumer feedback resulting in products that are better able to do the things the new users require of them (for example, compare the operating systems of modern PCs with those of the mid 1980s). In the case of investment decision rules, our argument is that almost precisely the opposite is true, as the most powerful forms are the early ones and mass adoption often substantially degraded a rule's performance.

The *degeneration* of decision rules is easily modelled in a multi-agent replicator setting through imposing some kind of entropy condition on the adoption process and with replicator dynamic pay-offs of rules in relation to the population of others playing the same strategy. We have not pursued this exercise here. This is not because it raises too many specific issues to be treated in passing, but more because this approach ultimately relies on specific identification of the rules so as to code the multi-agent's behavioural repertoire and to seed the system appropriately. As with modelling, our research has not extended to that yet, and so we must leave this to future work, or to others. A variety of ethnographic methods could be used to identify rules used by different members of the real population, which could be used to seed such a model. For studying property investments, these could include verbal reports and protocol analysis (Ericsson & Simon, 1993), questionnaires and focus groups, and studies of text from real estate journalists and 'how to invest in real estate' books and seminars.

This paper could be said to be considering decision rules as memes, in the sense suggested by Dawkins (1976), i.e. as replicators of cultural information that one mind transmits to another. As such, it shares a problem with memetic thinking, which treats memes as fundamental units and tends to take them for granted in studying their transmission and the effects of this: in focusing on the degradation of decision rules as they spread through the population of decision makers we have not addressed the question of how novel rules come to be generated at the start of the process. To address this question, it will probably be useful to augment the present evolutionary/behavioural perspective with inputs from research on entrepreneurship inspired by Austrian economists, particularly the work of Kirzner (1973), who sees entrepreneurship as arising from an alertness to opportunities for making money. Since potential ways of making money are not tagged as such, merely waiting to be discovered, alertness must begin with entrepreneurs *creatively* forming constructs about where it might be possible to make money (typically by making new connections between existing ideas or investing in second-order rules for originating and adopting new decision rules), and then appraising the quality of their conjectures before, so to speak, placing their bets in financial terms (see Dopfer & Potts, forthcoming; Earl, 2003; Harper, 1996). Clearly, there is considerable scope for psychology to be useful here, not merely research on creative thought processes but also the ‘constructionist’ literature inspired by Kelly’s (1955) *Psychology of Personal Constructs*, research methods from which seem well suited for comparing differences between how the market in question is viewed by those who originate decision rules and those who attempt to follow them.

The ability to model the circumstances under which influential decision makers will pioneer new rules and cease employing their versions of rules that others have been latching on to is clearly important if we are to be able to anticipate the fading away of the original rule and mutations of it from the decision repertoire of others. There is something of a parallel here with the way in which scientific disciplines (including economics) evolve, with ideas percolating down from leading-edge researchers and paradigms/scientific research programmes occasionally being displaced by others that can deal with anomalies better or otherwise are judged as more promising. However, in the case of the rise and fall of decision rules in economic systems, the situation is complicated by a reflexive dimension, in which the spread of rules has an impact on the environment with which the rules were intended to deal. Thus although the rule pioneers might be like Kirznerian entrepreneurs, constantly on the look out for/trying to construct better ways of improving their wealth, they might instead operate in a problem-solving manner, only seeking to come up with new rules when their existing ones cease to function effectively due to events in the market that are consequent on their rules having been adopted by others, with or without suffering degradation. In the latter case, the operation of markets will have a self-sustaining dynamic whose path will depend on who experiments with new rules and how people change their rules for judging whom to take seriously as sources of effective decision rules. Percolation models from physics, such as those reviewed in Watts (2003), might be adaptable to economics for modelling such processes.

6. Conclusion

This paper has introduced the notion of a decision-rule cascade as a means of explaining interdependent changes in the speculative decisions that people make and how this can result in the sorts of herding phenomena that, given certain conditions of optimism and

liquidity, seem to manifest recurrently in stock-market and real-estate booms and bubbles. These macro-dynamics have micro-foundations that turn upon the heterogeneity of agents and the way they learn new investment rules. The explanation of why things go up is the same as the explanation of why things go down, namely the evolutionary consequence of the adoption of new behavioural rules. We have considered this mainly in the specific context of speculative investment in residential property, but the principle is general. The structure of investment is a function of the investment rules that agents have acquired and the structure of these rules evolves whenever new rules are introduced and are subsequently adopted and retained. Sometimes this leads to wealth creation; sometimes it leads to bubbles. The outcome is necessarily uncertain.

This behavioural/evolutionary analysis presented here is intended to complement Minsky's (1975) extension of Keynes's work in which the focus is on the changes that occur in agents as a boom gathers pace and the mood of market participants goes from cautious to euphoric and so the proportion of the population engaging in speculation goes from few to many. Our general point is that, across the spectrum of financial assets, this is something that happens rather regularly and not rarely. Like Minsky, we see the investment process as prone to result in some speculators making expensive errors, and this is particularly likely where novices pick up and apply degraded versions of decision rules late in a boom. The cascade process we have outlined here is not inherently a cascade towards all speculators using broadly the same rule as an equilibrium adjustment, for although all rules are socially transmitted, and although people will have a variety of rules between which to choose, they will also have no obvious rule for working out which rule is yet the best one. There is no solution to the rational investment problem because every strategy promotes a higher-order counter-strategy. Such is the permanently restless condition of all speculative markets that lie beyond the realm of known probabilities and so define the realm of *fundamental uncertainty* (Shackle, 1972, 1974). In such a world, speculative bubbles are just as likely as depressive slumps because knowledge can grow as a function of the optimism or pessimism laden in the investment rules acquired by agents along the way.

References

- Baddeley, M. (2005). Housing bubbles, herds and frenzies: Evidence from British housing markets. CEPP Policy Brief, no. 02.05, Department of Land Economy, University of Cambridge. Available from http://www.landecon.cam.ac.uk/real_estate_grp/econ_and_public_polic/PUBLICATIONS_CCEPP_files/pb0205.pdf.
- Bannerjee, A. (1992). A simple model of herd behavior. *Quarterly Journal of Economics*, 107, 797–817.
- Bikhchandani, S., Hirshleifer, D., & Welch, I. (1992). A theory of fads, fashion, custom, and cultural change as informational cascades. *Journal of Political Economy*, 100, 992–1026.
- Boland, L. A. (1986). *Methodology for a new microeconomics*. London, UK: Allen & Unwin.
- Chancellor, E. (1999). *Devil take the hindmost: A history of financial speculation*. New York, NY: Plume.
- Coddington, A. (1976). Keynesian economics: The search for first principles. *Journal of Economic Literature*, 14, 1258–1273.
- Dawkins, R. (1976). *The selfish gene*. Oxford, UK: Oxford University Press (2nd ed., 1989).
- De Vany, H. (2004). *Hollywood economics: How extreme uncertainty shapes the film industry*. London, UK and New York, NY: Routledge.
- Diamond, D., & Dybvig, P. (1983). Bank runs, deposit insurance, and liquidity. *Journal of Political Economy*, 91, 401–419.
- Dopfer, K., Foster, J., & Potts, J. (2004). Micro meso macro. *Journal of Evolutionary Economics*, 14, 263–279.
- Dopfer, K. & Potts, J. (forthcoming). *The general theory of economic evolution*. London, UK: Routledge.
- Dorogovtsev, S. N., & Mendes, J. F. F. (2003). *Evolution of networks: From biological nets to the Internet and WWW*. Oxford, UK: Oxford University Press.

- Earl, P. E. (1986). *Lifestyle economics consumer behaviour in a turbulent world*. Brighton, UK/New York, NY: Wheatsheaf Books/St Martin's Press.
- Earl, P. E. (Ed.). (2001). *The legacy of Herbert Simon in economic analysis*. Cheltenham, UK: Edward Elgar.
- Earl, P. E. (2003). The entrepreneur as a constructor of connections. In R. Koppl (Ed.), *Austrian economics and entrepreneurial studies: Advances in Austrian economics* (Vol. 6, pp. 113–130). Amsterdam: JAI/Elsevier.
- Earl, P. E., & Potts, J. (2004). The market for preferences. *Cambridge Journal of Economics*, 28, 619–633.
- Earl, P. E., & Wakeley, T. (2005). *Business economics: A contemporary approach*. Maidenhead, UK: McGraw-Hill.
- Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis: Verbal reports as data*. Cambridge, MA: MIT Press.
- Harper, D. A. (1996). *Entrepreneurship and the market process: An enquiry into the growth of knowledge*. London, UK and New York, NY: Routledge.
- Hodgson, G., Samuels, W., & Tool, M. (Eds.). (1994). *The Elgar companion to institutional and evolutionary economics*. Aldershot, UK: Edward Elgar.
- Kelly, G. A. (1955). *The psychology of personal constructs*. New York, NY: Norton.
- Keynes, J. M. (1936). *The general theory of employment, interest and money*. London, UK: Macmillan.
- Keynes, J. M. (1937). The general theory of employment. *Quarterly Journal of Economics*, 51, 209–223.
- Kirzner, I. (1973). *Competition and entrepreneurship*. Chicago, IL: University of Chicago Press.
- Minsky, H. P. (1975). *John Maynard Keynes*. New York, NY: Columbia University Press.
- Morrison, K. (2004). Asset price dynamics under networked expectations, Honours thesis, School of Economics, University of Queensland.
- Nelson, P. (1970). Information and consumer behavior. *Journal of Political Economy*, 78, 311–329.
- Nelson, R., & Winter, S. (1982). *An evolutionary theory of economic change*. Cambridge, MA: Harvard University Press.
- Peng, T.C. (2004). Mainstream vs. heterodox perspectives on the dynamics of the Brisbane residential property market 1998–2003. Masters thesis, School of Economics, University of Queensland.
- Polanyi, M. (1958). *Personal knowledge*. London, UK: Routledge & Kegan Paul.
- Porter, M. (1980). *Competitive strategy*. New York, NY: Free Press.
- Raines, P., & Leathers, C. (2000). *Economists and the stock market: Speculative theories of stock market fluctuations*. Cheltenham, UK: Edward Elgar.
- Ryle, G. (1949). *The Concept of Mind*. London, UK: Hutchinson.
- Shackle, G. L. S. (1972). *Epistemics and economics: A critique of economic doctrines*. Cambridge, UK: Cambridge University Press (republished in 1992, New Brunswick, NJ: Transaction Publishers).
- Shackle, G. L. S. (1974). *Keynesian kaleidies*. Edinburgh, UK: Edinburgh University Press.
- Shiller, R. (2000). *Irrational exuberance*. Princeton, NJ: Princeton University Press.
- Sornette, D. (2003). *Why stock markets crash: Critical events in complex financial systems*. Princeton, NJ: Princeton University Press.
- Sornette, D. (2004). *Critical phenomena in natural sciences: Chaos, fractals, selforganization, and disorder: Concepts and tools* (2nd ed.). Berlin: Springer.
- Watts, D. (2003). *Six degrees: The science of a connected age*. London, UK: Heinemann.
- Williamson, O. E. (1975). *Markets and hierarchies*. New York, NY: Free Press.
- Witt, U. (2003). *The evolving economy*. Cheltenham: Edward Elgar.