INVITED DISCUSSION PAPER[1]

SURPRISE, SURPRISE
FROM NEOCLASSICAL ECONOMICS TO E-LIFE[2]

BY

DAVID INGRAM, PAUL TAYLER AND MICHAEL THOMPSON

ABSTRACT

We build and describe an agent-based model: the Surprise Game. The game comprises a "world" of 30 firms, each of which has to survive (and, if possible, prosper) in its environment, which is nothing more than the other 29 firms. Each firm has to latch onto one or other of the four strategies that are predicted by the theory of plural rationality but has to relinquish that strategy and latch onto one of the others if it finds itself surprised. This model illustrates the dynamics of the world as described by the *theory of plural rationality* which are more similar to the dynamics of the actual world than economic models that assume equilibriums that are occasionally disturbed by shocks. This model and the theory of plural rationality provide insights and ideas for further work for actuaries.

INTRODUCTION

The Surprise Game agent-based model comprises a "world" of 30 firms, each of which has to survive (and, if possible, prosper) in its environment, which is nothing more than the other 29 firms. Each firm (*automaton*) has to latch onto one or other of the four strategies that are predicted by the theory of plural rationality (thereby becoming *agents*; hence agent-based modelling) but has to relinquish that strategy and latch onto one of the others if it finds itself surprised in three (though that number can be varied) consecutive rounds of the game.

---

[1] This paper presents a new way of thinking about how markets work and different agents react to changing circumstances.
The editor invites readers to submit short discussions and longer articles that develop the ideas in a rigorous scientific direction.

[2] First presented at the International Institute for Applied Systems Analysis/Konrad Lorenz Institute workshop – The Human Brain and the Social Bond, Vienna, 2010.

Astin Bulletin 42(2), 389-411. doi: 10.2143/AST.42.2.2182803

For all its simplicity and abstraction, the game gives rise to some remarkably life-like behaviour: booms, downturns, waves of bankruptcies, periods of "merger mania" and so on. More life-like, in fact, than any of the behaviours that are generated by models based on economic theory (be it neoclassical or neo-institutional). And if it does this then we need to consider the theory that underlies the game as an economic theory.

First, there are no equilibria in it, anywhere. Second, in going from rational choice (just one way of organising) and the markets-and-hierarchies framing (two ways of organising) to the full complement that includes the other two ways (egalitarianism and fatalism), we move from simplicity to complexity: from a situation where you can write equations and solve them for equilibrium conditions to one in which all you can do is "e-life": building "bottom-up" models, such as the Surprise Game, and then playing around with them to see what happens. No need to feel disappointed, however, since e-life exploration, as we show, can explain, among other things, how the recent credit crunch/recession came about. Moreover, it can also help us to design ways of avoiding these sorts of large-scale collapses in the future.

Rather than insisting that we are all rational utility-maximisers (neoclassical economics) or all incapable (in the same irrational way) of behaving according to the tenets of neoclassical economics and therefore desperately in need of the wise guidance of hierarchy (behavioural economics), the Surprise Game suggests we should think in terms of individuals moving in and out of the different ways of organising in different parts of their lives (workplace and home, for instance).[3]

The Different Premises of Plural Rationality

"They will never agree", said the nineteenth-century wit, the Reverend Sidney Smith, when he saw two women shouting at each other from houses on either side of an Edinburgh street, "They are arguing from different premises". Theorists of plural rationality[4] (eg Douglas and Wildavsky 1982, 174; Adams 1995, 50) are fond of this story because it enables them to get to grips with the "structured disagreement"[5] that is so characteristic of debates about the state of the world and about what, if anything, needs to be done about it. The different

[3] This, of course, requires that their brains are capable (a) of "internalising" what is required by each of these ways of organising and (b) of switching to the appropriate one in response to cues that indicate that such a switch is needed. Neuroscientists, we find, see these requirements as perfectly feasible. It is the "all the same" (rational choice) and "all completely different" (post-structuralism) that they have trouble with.

[4] Sometimes called "cultural theory" and sometimes "neo-Durkheimian institutional theory". The latter, unfortunately, is too much of a mouthful, while the former risks conveying the impression that it is culture that is doing the explaining.

[5] "Structured" in the sense that each position, as we will see, defines itself in contradistinction to the others: a self-organising system, in other words.

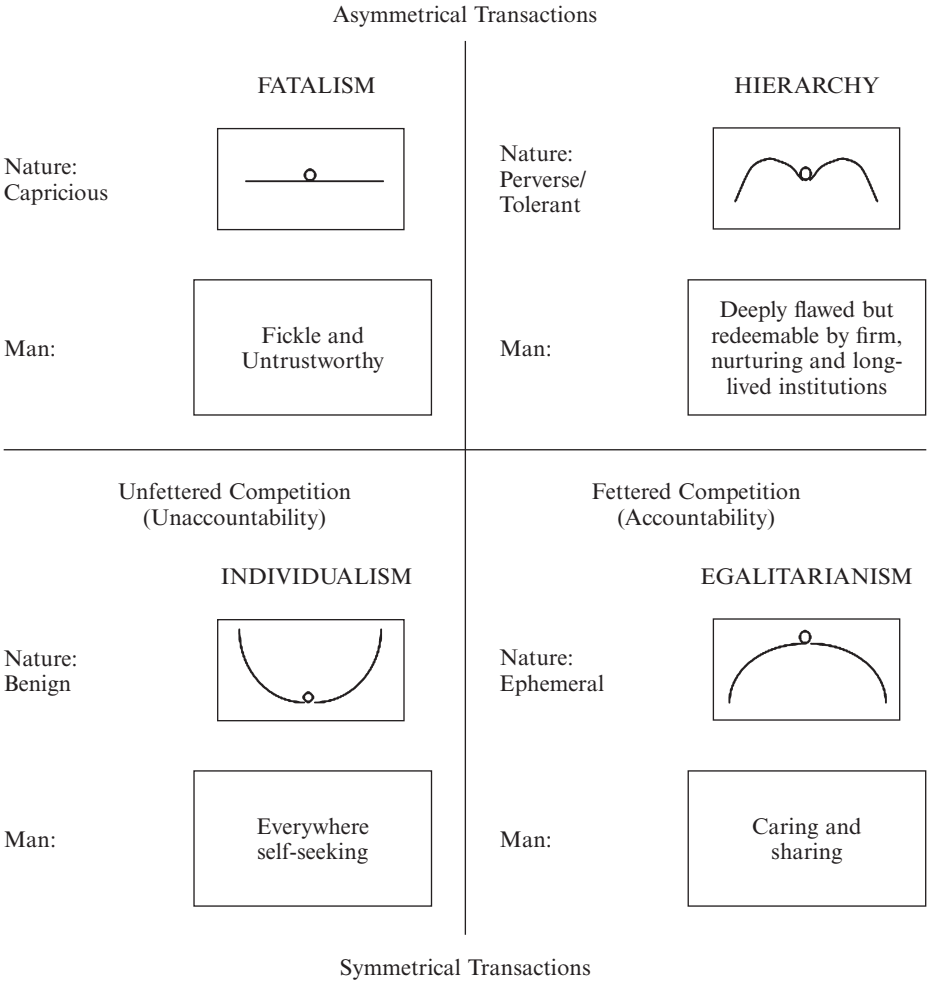

FIGURE 1: The Theory of plural rationality: the four forms of social solidarity and their associated premises (or myths of nature).

premises that are being argued from in these debates concern both physical and human nature, and the theory maps them in terms of a fourfold typology of what are called forms of social solidarity (Figure 1).[6]

[6] Properly speaking, the typology is fivefold, in that there is a somewhat "socially detached" solidarity – characterised by the hermit – within which it is possible to contemplate each of the other four sets of premises as "stills" within a cyclical sequence of transitions (see Thompson, Ellis and Wildavsky 1990; Thompson 2008). This, in some ways, is the position we will be adopting in writing this paper.

Though at first glance this may appear to be a daunting diagram, much of what it contains is pretty orthodox. Indeed, two of the forms of solidarity – *individualism* and *hierarchy* – have long been familiar to social scientists; institutional theorists, for instance, refer to them as *markets* and *hierarchies* (eg Williamson 1975; Lindblom 1977). The theory's novelty lies in its addition of the other two solidarities – *egalitarianism* and *fatalism* – and in the making explicit of the different sets of premises – the different *myths* (or social constructions or models) *of nature* (physical and human) – that sustain and justify these four fundamental arrangements for the promotion of social transactions.

The term "social solidarity" comes from the great French sociologist Emile Durkheim, and social solidarities are nowadays defined as the different ways in which we bind ourselves to one another and, in so doing, define our relationship with nature. The argument (and it is not one that is easily grasped) is that it is the social solidarities – the contending ways of relating, perceiving, acting and justifying – that are the units of analysis, not the individual. Indeed, it makes more sense to speak (as the indianist McKim Marriott [1967] has long spoken) of the *dividual*, since we all move in and out of different solidarities in different parts of our lives: workplace and home, for instance. So it would be a mistake to expect to be able to draw any direct comparisons between the theory of plural rationality and those seemingly more commonsensical theories that take the individual as the unit of analysis: neoclassical economics, behavioural economics, decision theory, evolutionary psychology and so on. All this is particularly troublesome when it comes to efforts to apply and test the theory in terms of quantitative social science (including game theory), because that field is so massively imbued with *methodological individualism* (or, as Mary Douglas used to say, "the individualist fallacy").

Hierarchies (coming back to Figure 1) institute status differences: asymmetrical transactions, that is (as in Boston where, it is said, "Lowells speak only to Cabots, and Cabots speak only to God"). And hierarchies, by requiring forms of behaviour appropriate to those of differing rank and station (accountability, that is), set all sorts of limits on competition. Markets – the transactional arrangements that accompany individualism – do the diametrical opposite; they institute equality of opportunity (symmetrical transactions, that is) and promote competition (no accountability, that is, as in "If I don't do it someone else will").[7] The other two permutations – symmetrical transactions with accountability (labelled "egalitarianism" in the plural rationality scheme) and

[7] The word "accountability" is used by theorists of plural rationality in a number of ways. Mary Douglas saw each of her four "cultural biases" as providing the means by which the upholders of the solidarities could give an account of themselves, and this idea has also been used by Schwarz and Thompson (1990). Gross and Rayner (1985) have been careful to point out that, in the hierarchical solidarity, accountability runs in the opposite direction to status; it is the lowerarchs who are able to pull back into line those at the higher levels who are behaving inappropriately (devotees of Kenneth Grahame's *The Wind in the Willows* will recall that this is what the creatures of the riverbank did to Toad of Toad Hall). And it is in this sense of being able to hold others accountable that the word is being used here.

asymmetrical transactions without accountability (labelled "fatalism" in the plural rationality scheme) tend to be ignored by social science in general and by policy science in particular. And it is this shortcoming, as it is played out in the field of financial risk, that we will be seeking to remedy in this paper. First, however, we must quickly run through the four solidarities (and it will be helpful here to refer back to Figure 1).

- For upholders of the *individualist* solidarity, nature is benign and forgiving – able to recover from any exploitation (hence the iconic myth of nature: a ball that, no matter how profoundly disturbed, always returns to stability) – and man is inherently self-seeking and atomistic (like the "island" that, John Donne argued, "No man is"). Trial and error, in self-organizing ego-focused networks (markets), is the way to go, with Adam Smith's invisible hand ensuring that people only do well when others also benefit. Individualist actors, in consequence, trust others until they give them reason not to and then retaliate in kind (the winning "tit for tat" strategy in the iterated Prisoner's Dilemma game [Rapoport 1985]). They see it as only fair that (as in the joint stock company) those who put most in get most out. Managing institutions that work "with the grain of the market" (getting rid of environmentally harmful subsidies, for instance) are what are needed.

  This is the voice that calls for de-regulation, for the freedom to innovate and take risks, and for the internalization of environmental costs so as to "get the prices right".

- Nature, for those who bind themselves into the *egalitarian* solidarity, is almost the exact opposite (hence the ball on the up-turned basin) – fragile, intricately interconnected and ephemeral – and man is essentially caring and sharing (until corrupted by coercive and inegalitarian institutions: markets and hierarchies). We must all tread lightly on the earth, and it is not enough that people start off equal; they must end up equal as well – equality of result. Trust and levelling go hand-in-hand, and institutions that distribute unequally are distrusted. Voluntary simplicity is the only solution to our environmental problems, with the "precautionary principle" being strictly enforced on those who are tempted not to share the simple life.

  This is the voice that defines the opposite of development as hospitality, that scorns the idea of "trickle down" and instead seeks to target "the poorest of the poor". It is the voice that argues for zero-growth, and that calls urgently for major shifts in our behaviour so as to bring our profligate consumption down within the limits that have been set by Mother Nature.

- The world, in the *hierarchical* solidarity, is controllable. Nature is stable until pushed beyond discoverable limits (hence the two humps), and man is malleable: deeply flawed but redeemable by firm, long-lasting and trustworthy institutions (as in the headmasterly "Give me the boy and I will give you the man"). Fair distribution is by rank and station or, in the modern context, by need (with the level of need being determined by an expert and dispassionate

authority). Environmental management requires certified experts (to determine the precise locations of nature's limits) and statutory regulation (to ensure that all economic activity is then kept within those limits).

This is the voice that talks of "global stewardship", that readily invokes the *fallacy of composition* (that what is rational for the parts – belt-tightening during a recession, say – may be disastrous for the whole) and that insists that global problems (such as climate change) demand global solutions.

- *Fatalist* actors (or perhaps we should say non-actors) find neither rhyme nor reason in nature, and know that man is fickle and untrustworthy. Fairness, in consequence, is not to be found in this life, and there is no possibility of effecting change for the better. "Defect first" – the winning strategy in the one-off Prisoner's Dilemma – makes sense here, given the unreliability of communication and the permanent absence of prior acts of good faith. With no way of ever getting in sync with nature (push the ball this way or that and the feedback is everywhere the same), or of building trust with others, the fatalist's world (unlike those of the other three solidarities) is one in which learning is impossible. 'Why bother?' therefore, is the rational management response.

  Fatalist actors don't really have a voice; if they had they wouldn't be fatalistic! Nevertheless, since time and money that are spent on something about which nothing can be done is time and money wasted, there is some wisdom here that should not be ignored.[8]

These four solidarities, in varying strengths and patterns of pair-wise alliance, are clearly discernible almost anywhere you care to look: in debates over water

[8] The alert reader will have noticed that we have given game theory illustrations for the individualist and fatalist solidarities but not for the two "collectivised" ones: hierarchy and egalitarianism. The reason is that, because of social science's afore-mentioned bias towards methodological individualism, such illustrations are not straightforward. With both individualism and fatalism, the social constructions of human nature are close to the assumptions of methodological individualism: in the individualist solidarity, psycho-physiological entities (we must be careful not to call them "individuals"), each equipped with his/her distinctive preference set, are able to simultaneously transact with, and build trust in, one another; in the fatalist solidarity, a "beggar-my-neighbour" logic dismantles trust as quickly as it is formed. And the iterated and one-off prisoner's dilemma games nicely capture these crucial distinctions.
In what are called *public goods games* we encounter "punishers" and sometimes also a consideration of the "costs of punishing", since these seem to outweigh the benefits and yet do not deter the punisher. This, theorists of plural rationality would observe, is hierarchical behaviour that is being obscured by game theory's individualistic assumptions (there are endless papers and conferences on "the evolution of altruism" but not one on "the evolution of selfishness"!). "Duty", "honour" and "sacrifice" would be the appropriate hierarchical terminology, and of course those who, when the occasion demands it, make the "ultimate sacrifice" do not pause to count the cost.
Sacrificial behaviour can be even more pronounced in the egalitarian solidarity, with its uncompromising insistence that "we all sink or swim together". The mass suicide by the Jewish defenders of Masada when they found themselves surrounded by their Roman adversaries is a good example: one that theorists of plural rationality would suggest would be evident in *common-pool games* (though, of course, game theorists have not got round to those yet).

engineering in South Asia (Gyawali 2001; Thompson and Gyawali 2007); in international fora where delegates struggle to do something about climate change (Thompson, Rayner and Ney 1998; Verweij 2006); in the different ways international regimes cope with trans-boundary risks such as water pollution (Verweij 2000) and municipalities go about the business of transport planning (Hendriks 1994); in the various ways households set about making ends meet (Dake and Thompson 1999); in the different diagnoses of the pensions crisis in countries with ageing populations (Ney 2009); and in the different panaceas that are variously championed and rejected by theorists of public administration (Hood 1998), to mention but a few. And our aim in this paper is to add one more application to this list: financial risk.

In all these examples we have just listed we find that each solidarity, in creating a context that is shaped by its distinctive premises, generates a storyline that inevitably contradicts those that are generated by the other solidarities (Thompson and Rayner 1998; Douglas, Thompson and Verweij 2003; Ney 2009). Yet, since each distils certain elements of experience and wisdom that are missed by the others, and since each provides a clear expression of the way in which a significant portion of the populace feels we should live with one another and with nature, it is important that they all be taken some sort of account of in the policy process. That, in essence, is the case for *clumsiness* (Verweij and Thompson 2006; Verweij 2011), clumsiness being the state of affairs in which each of the "active" solidarities (hierarchy, individualism and egalitarianism) is (a) able to make its voice heard and (b) is then responsive to the others.

Clumsiness may look a little less strange if we point out that these two dimensions – *accessibility* and *responsiveness* are at the very heart of Robert Dahl's (1989) theory of pluralist democracy. And that democratic insight suggests that, if a firm (say) is carrying out a scenario planning exercise, it will need to ensure that all three storylines are fully developed into scenarios that are then engaged with one another. The climate change scenarios developed by the Intergovernmental Panel on Climate Change (IPCC), for instance, have been shown to all be elaborations of the hierarchical storyline (Janssen 1996). And Shell's scenarios – Shell is famous for its pioneering of scenario planning – have consistently missed out the egalitarian storyline (Elkington and Trisoglio 1996).

All this suggests that making yourself (or, rather, your organisation) clumsy is not going to be easy, even when you are trying to *be* clumsy. And, of course, many organisations are not even trying: all those international development agencies that until very recently were clustered around the "Washington consensus", for instance. So we have devised a little agent-based model – we call it the Surprise Game – in order to help those who want to make themselves clumsy to actually do it. First, we will show how the theory of plural rationality enables you to get started with the Surprise Game; second, we will explain where that game takes you (onto a strategic terrain that we call *rational adaptability*); third, we will conclude by saying something about what its implications may be: for economic theory and for actuarial practice.

Getting started, with plural rationality's help

The central hypothesis in the theory of plural rationality is that the way we are caught up in the process of social life (in hierarchically-structured relations, in ego-focused networks, in egalitarian enclaves, and so on) supplies us with our convictions as to how the world is (stable within limits, able to take anything we throw at it, everywhere fragile, and so on). Mother Nature, however, cannot always comply. In these non-compliant circumstances there will be a persistent, and very likely growing, mismatch between what we expect to happen and what actually happens. In contrast to those situations where the world happens to be the way we are insisting it is (think of Alan Greenspan and his 40 years of being served so well by his "self-interest ideology") our behaviour is penalised rather than rewarded (by, in Alan Greenspan's case, a "once-in-a-century credit tsunami"). This means that, sooner or later, as Frank Sinatra was always telling us, something's gotta give.

What it is that gives, and how, depends of course on the particular mismatch – on just how the world actually is and on just how we happen to be insisting it is – and this means that surprises, when they come, can come in a total of 12 different ways (Figure 2).

Our four kinds of actors have been identified in this figure by labels that, we have found, make them more readily accepted by those who work in the general area that goes by the name of Enterprise Risk Management (ERM). But, apart from that, we are sticking with our plural rationality diagram (Figure 1) particularly with its four "icons": the four little pictures of balls in landscapes. These myths of nature, incidentally, come not from anthropology but from the work of ecologists who have studied *managed* ecosystems: forests, grasslands, fisheries and so on (Holling 1986; Holling, Gunderson and Peterson 1993). These ecologists found that those who were doing the managing often took strikingly different decisions in situations that were ecologically identical. Some started spraying the forest with insecticide, for instance, while others stopped.

The myths of nature, therefore, are not falsehoods. Rather, they are the minimal representations of reality that must be ascribed to those managing institutions if they are to be seen as rational. Hence our theory's name. We mention all this so as to make clear that, with its wide range of areas of application and its bold inter-disciplinarity, this is really a *systems theory* that happens to have originated in anthropology. So perhaps it is exactly what we need if we are to get to grips with the *systemic risks* that, as all the pundits have been pointing out, were completely ignored in the run-up to the credit crunch.

Along the matrix's top-left to bottom-right diagonal (Figure 2), where the world is indeed the way it is stipulated to be, there are no penalties and therefore no surprises, but in each of the remaining 12 boxes there are. In order to deduce what each of these surprises will be we need to contrast the sorts of behaviour – "what's the point?" (Nature Capricious – fatalism), "tread lightly on the earth" (Nature Ephemeral – egalitarianism), "who dares wins" (Nature

ACTUAL WORLD / EXPECTED WORLD	UNCERTAIN	RECESSION	BOOM	NORMAL
PRAGMATIST (Fatalism)	ALLIGNED (No surprises)	Expected windfalls don't happen	Unexpected runs of good luck	Unexpected runs of good and bad luck
CONSERVATOR (Egalitarianism)	Caution does not work	ALLIGNED (No surprises)	Others prosper (especially individualistic strategists)	Others prosper (especially hierarchical strategists)
MAXIMIZER (Individualism)	Skill is not rewarded	Total collapse (when none was expected)	ALLIGNED (No surprises)	Partial collapse
MANAGER (Hierarchy)	Unpredictability	Total collapse (when only partial was expected)	Competition	ALLIGNED (No surprises)

FIGURE 2: A Typology of Surprises

Benign – individualism) and "look before you leap" (Nature Perverse/Tolerant – hierarchy) – that are sensible and morally justifiable to the inhabitants of each of the stipulated worlds with the responses such behaviour will provoke in each of these actual worlds.

- In Nature Capricious there is no discoverable pattern to the responses: the world is an enormous fruit-machine.
- In Nature Ephemeral there is a discoverable order: the world is a vast negative-sum game.
- In Nature Benign the reverse is the case – the world is a huge positive-sum game.
- In Nature Perverse/Tolerant there are two games going on – a positive-sum one and a negative-sum one – but (unlike Nature Capricious) there *is* a discoverable order: it is possible to differentiate between those situations in which one game is operating and those in which the other holds sway.

For instance, if we have stipulated a world (Nature Capricious) in which learning is not possible, when in fact we occupy one in which it is, then we will be slow to pick up on all the recurrent regularities that are being thrown up around us. And when we do begin to pick up those regularities – when we begin to learn (in one or other of the three possible ways of learning that this typology gives us) – then, inevitably, we will find ourselves being eased away from the fatalist myth of nature and being brought under the thrall of one of the others. Conversely, if we have stipulated a world – Nature Perverse/Tolerant – in which there is a clear boundary between equilibrium and disequilibrium, when in fact the world we occupy is flat and featureless, then try as we may (and we will!) we will not be able to obtain the crucial information that we need if we are to act rationally (ie in a way that will uphold the particular patterns of relationships – hierarchy – that we have bound ourselves into).[9] Our information costs, as we put our strategy of certainty-creation to work, will shoot off to infinity, and our resources (which we have defined as limited but expandable within the positive-sum portion of our world) will drain away into a plugless sink. The hierarchical strategy, of course, will probably lead us to switch resources to some other area of information needs, but if the world is everywhere flat we will just be switching them from one plugless sink to another. Eventually, as we learn that learning is not possible, we will find ourselves abandoned by the hierarchical myth of nature and embraced by the fatalist myth: Nature Capricious. And so it goes, each in its distinctively surprising way, for the other ten possible mismatches.

So our typology not only tells us how the various surprises differ; it tells us just how nice or nasty they are likely to be. To discover that you win Life's Lottery more often than you expected you would (row I, column III) is to be quite pleasantly surprised; to experience total system collapse (rows III and IV, column II) is to be rather unpleasantly surprised. So we can give a positive or negative value to each of the surprises. Our typology is then transformed into what game theorists call a "pay-off matrix". Game theorists, however, usually start off with some game ("Chicken", say, or "The Prisoner's Dilemma"), re-describe it as a set of rules, and then triumphantly deduce the pay-off matrix. Here, we have the reverse situation. We already have the pay-off matrix; the challenge is to discover what the game is! Our predicament is akin to those jokes where you are told the punch-line and have to try to work out what the question is (for example, "9W"; question: "Tell me, Professor Wittgenstein, do you spell your name with a V?"). Our answer is provided in the form of our agent-based model, the Surprise Game.

---

[9] We have no objection to the idea of *rational choice*; just to the addition of the word "theory". "A rationality", as Grauer, Thompson and Wierzbicki (1985, p4) have stressed, "is a conceptual framework for perceiving what constitutes rational action". Only if you have a set of hypotheses as to the nature of these conceptual frameworks – how many of them there are, how they differ, where they come from, how they interact and so on – can you speak of a theory.

The surprise game

In the Surprise game, we have populated a computer simulation world with 30 economic agents or firms. At the outset, we assign them to the four solidarities. But instead of defining rules of behaviour and divining a payoff matrix, we start with the payoff matrix in the form of the Typology of Surprises in Figure 2.

In addition, we specify how the world will interact with the agents. The environment for these firms is not *surprised* by the actions of the firms, but it is pressured to keep changing. For this Surprise Game, we have presumed a closed world with finite resources. In such a world, the growth imperative of the Maximizers will quickly put all of those resources at risk, pressuring the environment out of its Boom phase. The caution of the Conservators will result in a build-up of under-utilized resources which will cause pressure for the world to break out of a Recession. The Managers will slowly and capably build up the amount of resources at risk, eventually pressuring the world out of what they think of as the Normal phase of the environment. The Pragmatists' strategy is somewhere between those of Conservators and Managers and tends not to produce any pressure. But the randomness of their Uncertain environment will sooner or later seem to show a pattern that is either favourable or unfavourable, resulting in reinforcing behaviour from the other firms that causes the environment to shift in that direction.

As the environment shifts, the firms either encounter the surprises and change their outlook or else they fail to do this and are replaced by new firms which, at least at the outset, are in alignment with the environment. It is by this device that the game ensures that there is always the full complement of 30 firms, and their overall dynamics (over a run of half an artificial century) are summarised in Figure 3.

Within this Surprise Game world, the financial results of firms can be seen to vary according to their alignment with the environment. Many avid proponents

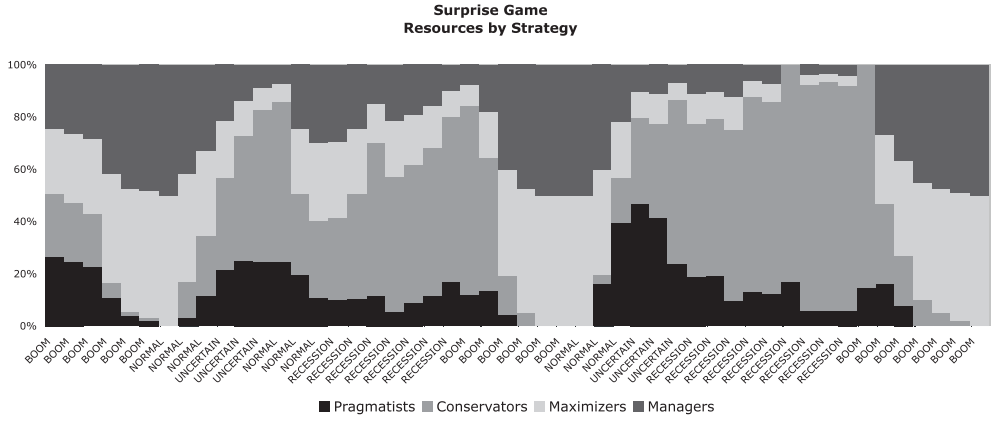

FIGURE 3: Fifty Years in the World of the Surprise Game

of one or another of the four solidarities would suggest that the best course would be for the firm to always stay with its original strategy. This strategy can be called "Stay the Course" and Table 1 shows the overall results for each of the four ways of Staying the Course.

TABLE 1

RESULTS OF STAY THE COURSE STRATEGY

	Average Return	Standard Deviation of Return	Failure Rate
Pragmatists	0	15.3	10.61%
Conservators	0	5.39	0.01%
Maximizers	4.28	32.08	26.96%
Managers	2.88	17.96	12.90%

The Conservators are seen to meet their strategic objectives. Their firms almost never fail under a Stay the Course strategy. But on the average, as the world shifts among the four risk environments, they also achieve zero returns, with a small amount of variance up and down. Pragmatists also achieve no returns, but have both a substantial variance of returns and failure rate. Maximizers and Managers both achieve small returns, though much lower than their expectations. And they each show substantial variances of returns. Maximizers show a failure rate of over 25% when they Stay the Course. This modelled result had some real life confirmation when the two large US investment banks (Bear Stearns and Lehman Brothers) that stayed with their pure Maximizer behaviours were the largest casualties in the early days of the Global Financial Crisis.

In fact, the Surprise Game suggests that the imperatives of the Surprise Typology (Figure 2) will usually result in some shifting of solidarity. The degree to which this shifting of solidarity aligns with the risk environments presents drastically different results for the firms as shown in Table 2. A shift to the solidarity that matches the new environment is considered a successful adaptation. So the Adaptation Success Rate is the measure of the degree to which the solidarity is in alignment with the environment.

TABLE 2

VARIATION OF RESULTS BY SUCCESS OF ADAPTATION

Adaptation Success Rate	Average Return	Standard Deviation of Return	Failure Rate
0%	–1.69	19.35	19.97%
25%	1.94	20.12	16.09%
50%	5.56	20.21	12.19%
75%	9.19	19.64	8.32%
100%	12.81	18.46	4.76%

The 0% Adaptation Success Rate suggests that the firm never has the solidarity that aligns with the environment, always changing before a previous solidarity aligns. The ultimate bad luck firm. Those firms show results that are slightly worse than the Pragmatists who Stay the Course, but with twice their rate of firm failure. At the other extreme, the firm with 100% successful adaptation – the *rationally adaptable* firm – can achieve quite good returns over all phases of the environment, with moderate variance of returns and a fairly low failure rate.

The firm with the 25% success rate is getting it right as often as guessing would accomplish. A firm that simply follows the Surprise Payoff rules will achieve somewhere between the 25% and the 50% success rate in adaptation.

Some implications

Rather than insisting that we are all rational utility-maximisers (neoclassical economics) or all incapable, in the same irrational way, of behaving according to the tenets of neoclassical economics and therefore desperately in need of the wise guidance of hierarchy (behavioural economics),[10] the Surprise Game suggests we should think in terms of plural rationality: individuals moving in and out of different solidarities in different parts of their lives.

Since pretty well all the current debate is over whether neoclassical or behavioural economics is right, an approach that says they are both wrong is likely to be seen as having come out of nowhere: an unwelcome bolt from the blue, you might say. In fact, it has not come out of nowhere; it has come out of evolutionary economics (eg Nelson and Winter 1982; Arthur 2009). But, bolt from the blue or not, it is clearly going to have some implications.

Reversing Out of the Mathematized Cul-de-Sac

Economics, the Surprise Game suggests, took a wrong turn, back in the 1920s and 30s, when it mathematized itself and came up with its snappy new definition: the allocation of scarce resources to alternative ends.[11] Before then, scarcity was not such a crucial concept and the focus was much more on industrial organisation and technology (eg Adam Smith and his pin factory) and on the

[10] The behavioural economists themselves, curiously, are exempt from this supposedly universal irrationality; they, unlike the untutored masses, are able to discern what is rational. Moreover, they propose to harness that discernment to public policy: for instance, by spotting the appropriate moment and then "nudging" all the ignoramuses across to the rational behaviour: "We can make you behave. Our plan is to embed the insights gleaned from behavioural economics throughout government" (Osborne and Thaler 2010, George Osborne became Britain's Chancellor of the Exchequer in May 2010, four months after this article was published).

[11] This definition (worded slightly differently) comes from Lionel Robbins (1935). For the serious problems associated with a scarcity-based economic theory see Thompson (2010).

political economy of production processes (eg Karl Marx and the "industrial novelist" Elizabeth Gaskell). And Alfred Marshall, though one of Britain's leading mathematicians, steadfastly refused to bring those talents to bear on economics, on the grounds that to do so would be to obscure his over-riding aim: "to understand the forces that cause movement". A valid argument, we might reflect, in view of the fact that the massed ranks of mathematicians employed by the banks totally failed to anticipate the recent "movement" that precipitated the demise (or expensive bail-out) of many of those banks.

The work of one economist, Hyman Minsky (1992), however, has much in common with the Surprise Game. He suggested three general states of economic activity; Hedge, Speculative and Ponzi. And there is, of course, a fourth state that he also acknowledged: Collapse. Minsky argued that, in capitalist economies, there is a normal progression between these states.

- **Hedge.** Lending is primarily to businesses and individuals that clearly have the cashflows to support the repayment of the loan principal and interest. More financing is done via equity than through debt. No specific assumption on future values is needed to support economic activity.
- **Speculative.** Here cashflows of borrowers can fully support the payment of interest on debt, but not the repayment of principal. Debts are presumed to be repaid by refinancing. Debt is starting to overtake equity as a general method of financing. There is an assumption that values of assets in the economy will be the same or higher.
- **Ponzi.** Cashflow from borrowers is not sufficient to repay either principal or interest. Debt becomes almost the sole source of financing, and leveraged share purchases are common. There is an assumption that values are going to increase to be available to pay back principal and interest on debts.
- **Collapse.** Lending ceases, because lenders are uncertain about anyone's ability to pay either principal or interest. Business activity shrinks to the extent that debt was a necessity, and only activity that can be financed out of current cashflows continues. There is no certainty about future valuations of assets. Transition back to the Hedge state can be rapid or prolonged; the length of time spent in Collapse can be heavily influenced by government intervention in the markets.

Plural Rationality provides motivations for the actions within each state. In each state, the predominant economic actors believe that their actions are perfectly rational. The Egalitarian (Conservator) point of view aligns with the Collapse state, as collapse is what they expect. Individualists (Maximisers) believe that the Ponzi-financed schemes will actually turn out fine for everyone, because they believe in continual growth and low risk. The Speculative state is ruled by Hierarchists (Managers) who believe that the delicate balance of debt refinancing can work if things are well managed. And the short term focus of Hedge lending can be matched up perfectly with the expectation of uncertainty of the Fatalists (Pragmatists).

Nothing To Lose But Your Equilibrium

Agent-based modelling is not just another method that can be added to the current repertoire; if it comes in then most of the current repertoire goes out. "Artificial life" (which is what agent-based modelling takes us into) concentrates on the micro-level interactions in a system which lead, sometimes, to unexpected *emergent* behaviour of the system as a whole. This, as we have just seen, is what happened with our Surprise Game. It was the 30 "firms" that were equipped with resources and strategies, and with the possibility of strategy-switching, and then allowed to get on with it. The unexpected total-system behaviour – the Kondratieff-like periodicity, for instance, and the endless disequilibration – then emerged. It was not there to start with, and that is what makes artificial life and agent-based modelling different from the more familiar forms of modelling. General equilibrium modelling, for instance, which is much relied on by economists, begins (as its name implies) by ruling out – from the top-down, as it were – all disequilibration. In other words, it *assumes* a state of affairs that we are suggesting does not, and could not exist.

Bottom-up modelling typically proceeds by specifying rules and relationships which govern the interactions between low-level constituents of the system: individual organisms, for instance, or cells (in an immune system, say), or people or, as in our Surprise Game, firms. This is in contrast to top-down modelling which normally specifies system behaviour through a series of equations that link global (that is, total-system) quantities: overall population size, for instance, or inflation rate, aggregate economic growth and so on. General equilibrium modelling, for instance, sets out from these sorts of equations which, among other things (insisting that all returns to scale are decreasing, to mention a rather crucial one), ensure that the market "clears". But of course if you want to model a disequilibrium system you cannot do this: you cannot write the equations and then solve them for equilibrium conditions, because there *are* no equilibria, and this means that bottom-up is the only way to go (Figure 4).

BOTTOM-UP (Agent-based)	TOP-DOWN (Aggregate)
Model specified by rules governing agent behaviour	Model specified by rules governing average behaviour
Global behaviour emerges from low-level interactions	Global behaviour specified by the model
Heterogenous populations (eg fourfold plurality of rationalities)	Homogenous populations (eg rational utility-maximisers)
Geography – spatial effects can be accommodated (eg by use of *cellular automata*): the detail matters	No spatial effects: the big picture is what matters (spatial and temporal wrinkles even themselves out in the aggregate)
Boundary conditions (eg barriers) easy to implement	Boundary conditions difficult
Evolution of agents (eg Marshallian movement) is feasible	Evolution of populations only

FIGURE 4: Some Crucial Distinctions

A-life has been much concerned with non-human behaviour, and with the sorts of questions that loom large for biological sciences. That is where the a-life discussion has, for the most part been; but a similar discussion, albeit not yet so well-explored, is possible in terms of the modelling of human behaviour: "e-life" as it is called. The Santa Fe Artificial Stock Market is a prime example (Tayler 1995) and our Surprise Game is another, and both are very much in the bottom-up spirit of evolutionary economics (pioneered by Nelson and Winter 1982; see Tayler 1990 for a discussion and explanation of related models).

Traditional economic modelling, by contrast (and as we have already observed), proceeds in a largely top-down fashion. This is clearly the case for macroeconomics, dealing as it does with aggregates like unemployment, inflation, economic growth and so on. However, even "microeconomic" theory is largely top-down too. Markets clear with a single price. Admittedly, there is the assumption of a price-demand curve, so implicitly not everyone in the model is identical, but in general all economic agents are homogenous in their knowledge and preferences, and there is typically little or no distinction made between them. How could there be if they are all assumed to have equal access to perfect information, and to act in a perfectly rational way? Traditional models, moreover, are static, ignoring evolutionary progress (in technological capability, for instance). Indeed, most forms of economic dynamism, leading as they do to increasing returns of some kind, are death to the equilibrium models of neoclassical economics.

We can conclude this section with what we feel is a clinching observation: that the theories of plural rationality and of surprise – with their fourfold differentiations of strategies, myths of nature and risk environments – are tailor-made for e-life, and e-life for them. But there is more to it than this. If the lifelike behaviour emerges only when the game encompasses all four strategies, myths and environments (the *requisite variety*), and if this sort of erratic cycling is what makes socio-economic evolution – Marshall's "movement" – possible, then economics really did take a wrong turn.

Finally, What About Actuaries?

The actuarial paradigm is closely related to the Hierarchical point of view: the Managers in our Surprise Game. Actuaries tend to believe that solutions to most problems can be found by careful actuarial analysis. They believe that the world is risky, but that the risk of the world can be managed if done carefully. The moderately risky, Perverse/Tolerant world is what actuaries expect. Unsurprisingly, they tend to thrive in organizations that rely heavily upon the analyses performed by actuaries and that give the actuarial function a clearly defined and well-respected role in their power structures.[12]

[12] Ingram and Underwood (2010a) describe the application of Plural Rationality to an ERM program and introduce the strategy of Rational Adaptability. Actuaries are urged to be open-minded about the

Applying the idea of Plural Rationality to actuarial work provides several lines of thought. First, the almost purely Hierarchical approach to problems that the actuarial training favours will be appreciated more within an organization where that is the predominant point of view. Even within such an organization, however, there will be predictable conflicts with Maximizers, Conservators and Pragmatists. While this is not new news to actuaries, plural rationality provides a systematic insight into the points of view of the various factions within the organizations where actuaries practice (Ingram and Underwood 2010b). The Surprise Game provides an illustration (but not an exact prediction) of how those dynamics shift in reaction to surprises. Actuaries can be aware that such dynamics are in action around them and adjust their work accordingly. Much of the actuarial literature is focused on ways to improve or even perfect actuarial analysis within the Hierarchical paradigm; new work could acknowledge that much actuarial work takes place within, or seeks to inform or influence, organizations that are primarily focused upon one or other of the other three paradigms that are identified by plural rationality. It could then identify how best to adapt the actuarial work (and/or the presentation of that work) to be most effective in these other three types of organizations.

Plural rationality also suggests to actuaries that the best tactical approaches to problems involving risk may vary with the variations in the risk environment. The approach currently favoured within the Hierarchical Perverse/Tolerant world view is to take full advantage of the advanced abilities of actuaries to carefully model all aspects of the choices presented to an organization and then to find the optimal combination of choices that provides the best outcomes with the least exposure to the more undesirable possibilities.

But in other environments, our Surprise Game suggests, these models will fail to provide the best answer. In the Benign environment, a simpler approach that puts much less emphasis on the undesirable outcomes will produce superior results, but in the Ephemeral environment, paying attention to making choices that minimize potential undesirable results will provide the best results. Finally, in the Capricious environment, no single approach or choice can be reliable, only broad diversification of approach and choices will be satisfactory.[13]

Finally, plural rationality's four environments provide a challenge to actuaries who are calibrating risk models and to those who seek to use those models to direct insurer risk strategies. The parameters for the models of the four environments are very different:

---

approach to risk management rather than focusing only upon the risk reward steering strategy of Manager-led firms.

[13] The four different ERM strategies are described in Ingram and Underwood (2010c). Further work since that publication suggests that many insurers will use different risk management strategies on different risks.

Environment	Drift	Volatility
Perverse/Tolerance (Normal)	Moderate	Moderate
Benign (Boom)	High	Low
Ephemeral (Recession)	Negative	Low
Capricious (Uncertain)	Variable	Variable

A single model could incorporate experience from all four environments, but it is difficult to see how such a model would give useful results for actions in any of the four environments.

The above lines of thought, we hasten to add, are highly tentative, and much further work is needed to determine how the insights from the Surprise Game about these four different models can be incorporated into actuarial practices.

References

Adams, J. (1995) *Risk*, London: UCL Press.

Arthur, W.B. (1989) Competing technologies, increasing returns and lock-in by historical events: the dynamics of allocation under increasing returns. *Economic Journal*, **99**, 116-131.

Arthur, W.B. (2009) *The Nature of Technology*. London: Allen Lane.

Dahl, R.A. (1989) *Democracy and Its Critics*. New Haven, Connecticut: Yale University Press.

Dake, K. and Thompson, M. (1999) Making ends meet: in the household and on the planet. *GeoJournal*, **47**, 417-424.

Douglas, M., Thompson, M. and Verweij, M. (2003) Is time running out? The case of global warming. *Daedalus*, Spring, 98-107.

Douglas, M. and Wildavsky, A. (1982) *Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers*. Berkeley, California: University of California Press.

Elkington, J. and Trisoglio, A. (1996) Developing realistic scenarios for the environment: Lessons from Brent Spar. *Long Range Planning*, **29(6)**, 762-769.

Grauer, M., Thompson, M. and Wierzbicki, A. (eds) (1985) *Plural Rationality and Interactive Decision Processes*. Berlin: Springer-Verlag (Lecture Notes in Economics and Mathematical Systems, 248).

Gross, J. and Rayner, S. (1985) *Measuring Culture: A Paradigm for the Analysis of Social Organisation*. New York, Columbia University Press.

Gyawali, D. (2001) *Water in Nepal*. Lalitpur, Nepal: Himal Books. (International edition published by Zed Books, London, as *Rivers, Technology and Society*, 2003).

Hendriks, F. (1994) Cars and culture in Munich and Birmingham: the case for cultural pluralism. In D.J. Coyle and R.J. Ellis (eds) *Politics, Policy and Culture*. Boulder, Colorado: West View Press.

Hood, C. (1998) *The Art of The State: Culture, Rhetoric and Public Management*. Oxford: Clarendon Press.

Ingram, D. and Underwood, A. (2010a) A The Full Spectrum of Risk Attitude, *The Actuary*, SOA.

Ingram, D. and Underwood, A. (2010b) The Human Dynamics of the Insurance Cycle and Implications for Insurers, *SOA Monograph Series*.

Ingram, D. and Underwood, A. (2010c) The Fabric of ERM, *The Actuary*, SOA.

Janssen, M. (1996) *Meeting Targets: Tools To Support Integrated Assessment Modelling of Global Change*. Den Haag: CIP-Gegevens Koninklijke Bibliotheek (ISBN 90-900 99 08-5)

Lindblom, C.E. (1977) *Politics and Markets: The World's Political-Economic System*. New York: Basic Books.

MARRIOTT, M. (1967) Hindu transactions: diversity without dualism. In B. Kapferer (ed) *Transaction and Meaning*. Philadelphia, Pennsylvania: Institute for the Study of Human Issues.
MINSKY, H. (1992) The Financial Instability Hypothesis. *The Jerome Levy Economics Institute Working Paper Series.*
NELSON, R. and WINTER, S. (1982) *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.
NEY, S. (2009) *Resolving Messy Policy Problems*. London: Earthscan.
OSBORNE, G. and THALER, R. (2010) We can make you behave. London: *The Independent*, 29 Jan.
RAPOPORT, A. (1985) Uses of experimental games. In M. Grauer, M. Thompson and A. Wierzbicki (eds) *Plural Rationality and Interactive Decision Processes.* Berlin: Springer-Verlag.
ROBBINS, L. (1935) *An Essay on the Nature and Significance of Economic Science*. London: Macmillan.
SCHWARZ, M. and THOMPSON, M. (1990) *Divided We Stand*. Philadelphia, Pennsylvania: University of Pennsylvania Press.
TAYLER, P. (1995) Modelling artificial stock markets using genetic algorithms. In S. Goonatilake and P. Treleaven (eds) *Intelligent Systems for Finance and Business*. Chichester: John Wiley.
THOMPSON, M. (2008) *Organising and Disorganising*. Axminster: Triarchy Press.
THOMPSON, M. (2010) A bit of the other: why scarcity is not all its cracked up to be. In L. Mehta (ed) *The Limits to Scarcity*. London: Earthscan.
THOMPSON, M., ELLIS, R.J. and WILDAVSKY, A. (1990) *Cultural Theory*. Boulder, Colorado: West View Press.
THOMPSON, M. and GYAWALI, D. (2007) Uncertainty revisited (new introduction). In M. Thompson, M. Warburton and T. Hatley, *Uncertainty on a Himalayan Scale*. Lalitpur, Nepal: Himal Books.
THOMPSON, M. and Rayner, S. (1998) Risk and governance part I: the discourses of climate change, *Government and Opposition*, **33(2)**, 139-166.
THOMPSON, M., RAYNER, S. and NEY, S. (1998) Risk and governance Part II: policy in a complex and plurally perceived world. *Government and Opposition*, **33(3)**, 330-354.
VERWEIJ, M. (2000) *Transboundary Environmental Problems and Cultural Theory: The Protection of The Rhine and The Great Lakes*. Basingstoke and New York: Palgrave Macmillan.
VERWEIJ, M. (2006) Is the Kyoto protocol merely irrelevant, or positively harmful, for efforts to curb climate change? In M. Verweij and M. Thompson (eds) *Clumsy Solutions for a Complex World*. Basingstoke: Palgrave Macmillan, 31-60.
VERWEIJ, M. (2011) *Clumsy Solutions For A Wicked World: How To Improve Global Governance*. Basingstoke: Palgrave Micmillan.
VERWEIJ, M. and THOMPSON, M. (eds) *Clumsy Solutions for a Complex World*. Basingstoke: Palgrave Macmillan.
WILLIAMSON, O. (1975) *Markets and Hierarchies*, New York: Free Press.

APPENDIX

THE SURPRISE GAME MODEL

The game is played by 30 "companies", each of which at each turn must hold one of the four beliefs about the environment in which their company operates.

Pragmatist (Fatalist)	Uncertain
Conservator (Egalitarian)	Bust
Maximizer (Individualist)	Boom
Manager (Hierarchist)	Moderate

The companies each have a reserve of cash, and an amount of capital invested in revenue producing business activity. Of course, that activity might in any

year product profits or losses. Each business would in each year choose how much to add to their capital investment, at a rate which depends on their belief about the business environment. The amount of investment is a constant fraction of their current cash balance and is added to the prior balance of capital investment.

Belief	**Investment Rate %**
Pragmatis	5%
Conservato	0%
Maximize	30%
Manage	15%

Maximizers are optimistic entrepreneurial types and invest heavily in the expectation of rewards, while Conservators risk nothing since they expect losses. Managers are cautiously optimistic, while Pragmatists do not invest much since they have low expectations. (Pragmatists might better be represented by a random amount of investment).

The rates of return of the invested capital are determined by the following table, which compares the company's belief about the environment (and hence the approach it has taken to the business) with the reality:

	Uncertain		Bust		Boom		Moderate	
	a	b	a	b	a	b	a	b
Pragmatist	10%	–10%	0%	–20%	20%	10%	10%	20%
Conservator	5%	–5%	–5%	–5%	5%	5%	0%	0%
Maximizer	20%	–20%	–30%	–30%	30%	30%	–20%	20%
Manager	10%	–10%	–20%	–20%	15%	15%	15%	15%

During the operation of the game, each year will have an environment chosen according to rules that are shown below, and in addition, there will be a random determination of whether it will be a type a or type b sub-environment. Additionally, the value from the above table will then be further treated as the mean of a uniform distribution that extends 5% above and below that value.

So, for example, a Pragmatist in an uncertain year would have an equal chance of getting any of the following returns:

15%	14%	13%	12%	11%	10%	9%	8%	7%	6%	5%
–15%	–14%	–13%	–12%	–11%	–10%	–9%	–8%	–7%	–6%	–5%

This payoff matrix contains the expectations of each belief (the situation where their strategy lines up with the environment).

Pragmatist	**either –10% or 10%**
Conservator	–5%
Maximizer	30%
Manager	15%

To a large extent you could say that the Surprise Game works differently from most Agent-Based Models, where a world is provided and a payoff matrix derived. In the Surprise Game, the payoff matrix is provided and the dynamic nature of the world results.

You can see that the matrix has Pragmatists having either positive or negative results in the a or b situations under any environment. This is because their approach produces less reliable results under any scenario. In addition, in the Uncertain environment, all of the companies with the other beliefs will have a chance of either a positive or negative result.

Maximizers will win big in the Boom environment that they expect, and will have compounded this gain with the large investment that they just made. However, the Maximizers will lose big in the Bust environment. Their results in the Moderate environment will be either large gains or large losses.

The Conservators will experience only very small gains or losses in all environments.

Managers will do well in their expected Moderate environment and show large gains in Booms and large losses in Busts, just not as large as the Maximizers. Their results in those extreme environments will be moderated by their investment amount being somewhat lower than the Maximizers.

The beliefs of the companies are not fixed. After three turns with any one belief a company will assess its experiences and the experiences of the other companies based upon the Surprise matrix. There is also a random element to any change decision. When a company decides to change, their decision of their belief for the following year will be made randomly from one of these five sets of choices:

1. All Four Beliefs
2. Pragmatist, Manager, Conservator
3. Pragmatist, Maximizer, Manager
4. Conservator, Manager, Maximizer
5. Maximizer, Manager

The decision to change is based upon two statistics about the company and two statistics about the entire group of companies.

OWNROR = Average rate of return for the company over the past three years
SIGN = Sum of the signs of the last three year's returns for the company (i.e. if the three prior years were all gains, then SIGN is 3, if they are all losses then SIGN is -3)
AVGROR = Average rate of return for the entire market of thirty companies. Weighted by size.
Top5 = Average rate of return for the top 5 firms.

The rules for changing then are:

a. For all companies, if OWNROR $< -10\%$ then change by rule 1

For Pragmatist Companies:

b. If SIGN = –3 then change by rule 2
c. If SIGN = 3 then change by rule 3
d. If Top5 > 20% then change by rule 3
e. If AVGROR > 10% then change by rule 3
f. If AVGROR < –10% then change by rule 2

For Conservators:

g. If OWNROR > 10% then change by rule 4
h. If TOP5 > 10% then change by rule 4
i. If AVGROR > 7.5% then change by rule 4

For Maximizers:

j. If OWNROR < 20% then change by rule 1

For Managers:

k. If OWNROR < 0 then change by rule 1
l. If TOP5 > 20% then change by rule 5
m. If AVGROR < 5% then change by rule 1

In addition to the 30 companies, the game has one more entity, the bank. The game is a closed system. The companies all start out with an equal amount of cash, and the bank also holds a balance of cash. Each year, as the companies make profits, their cash balance is increased by the amount of their profits and the bank's cash is decreased by that amount. Losses are deducted from their cash and added to the bank's cash.

When losses cause a firm's cash balance to go negative, the firm is bankrupt. It goes out of the game, its capital assets are converted back into cash and returned to the bank. The bank then finances the creation of a new firm in the place of the bankrupt firm. This new firm will have the belief that coincides with the business environment.

Finally, the environment is not fixed. As conditions change so the possibilities change, which results in pressure for a different environment. These changes will take place at most every three years. The rules for these changes are the following:

I. When the value of the cash held by the bank exceeds the total capital stock of the companies, then there is clearly room in the economy for expansion. Comparison of these two macro-economic variables provides a trigger for a jump to a Boom environment.

II. Because there are only fixed resources in the economy, there may come a point when the companies generate more profits than there is cash available in the bank to pay them. In other words, there is a ceiling, so that unlimited

expansion is not possible. So when this ceiling is hit, the environment shifts to a Moderate environment.

III. If the limit is hit repeatedly, then clearly the companies cannot all grow, but neither can they all be doing badly. If they were then they would be producing losses and refunding the bank. Furthermore, a growth strategy of high investment will not allow them to beat the competition, and will do no better or worse (necessarily) than a no-growth strategy. This state of disorder, where individual behavior makes little difference, is clearly the Uncertain environment and the trigger to change to that environment is that the ceiling should be touched in three out of any four successive turns.

IV. When too many companies go bankrupt, the economy is not working. That is a signal that a recession is coming on. There is a failure of business confidence. So when six or more companies have gone bankrupt (that is 20% of the entire economy) then the environment will shift into a Bust.

David Ingram
Executive Vice President,
Willis Re, New York City

Paul Tayler
Strategic Programme Lead,
National Health Service, UK

Michael Thompson
Senior Researcher,
International Institute for Applied Systems Analysis,
Laxenburg, Austria