Modeling the Variety of Decision Making

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Introduction

Static or deterministic actuarial models work with a single set of assumptions for all of the variables in the model. Most commonly, those assumptions might be selected to be the most likely values, or to values that produce an outcome for the model calculations that is likely to be achieved "most of the time" (i.e. most likely assumptions with provisions for adverse deviations). Deterministic models are also used in risk management related stress and scenario testing, where the assumptions are chosen to be static but at unlikely and adverse values.

It has become common in risk management related calculations to use dynamic or stochastic models. One or several of the key assumptions are set to vary under a set of rules and other assumptions as well as the ultimate calculations should vary along with the stochastic variables. And yet one assumption that is often held to be a static table of actions are the things that management has discretionary power to do in the future. Often called simply "management actions." Examples that relate to risk models include choices regarding execution of ALM and hedging programs, structure and extent of reinsurance purchases as well as underwriting standards and choice of the products/markets to do business. These management actions are usually the most critical in the lead up to and immediately following an experience of acute adverse experience.

This report presents the argument that (a) management actions cannot be definitively determined from past actions or current intentions; (b) there are a number of potential actions that management might take in and around times of adverse experience, and which of those actions that will be taken will be determined by the future management at that time based upon their vision at that time of the most likely potential future; and (c) an actuary can build this additional variability into a stochastic model to provide a more realistic range of future experience among the stochastic scenarios.

RISK ATTITUDES, STRATEGIES AND ENVIRONMENTS

We treat risk as something that can be measured but only if we have enough data and enough computer power and we follow the right highly complex methodologies. But risk is all about the future, and there are no facts about the future. All we can have is opinions.

These opinions can be classified into four risk attitudes: Pragmatists, who believe that the world is uncertain and unpredictable; Conservators, whose world belief is of peril and high risk; Maximizers, who see the world as low-risk and fundamentally self-correcting; and Managers, whose world is moderately risky, but not too risky for firms that are guided properly. Managers and Maximizers exhibit a belief in the legitimacy of models which is not shared by Conservators and Pragmatists (see Aggarwal et al., 2015).

Over time, these risk attitudes change via the process of surprise. Surprise is the persistent, and very likely growing, mismatch between what we expect to happen and what actually happens in the real world.

Because firms and individual managers have totally different risk attitudes, there is a varied and varying set of surprises that are happening all the time. Individual managers might expect a moderate market with fluctuations that follow past experiences; an uncertain market with unpredictable volatility; a market boom when everything seems to be going up; or a recession when everything seems to be going down. And business strategies are chosen because of an expectation of a market in one or the other of those states. This means that surprises, when they come, can come in 12 different ways, as shown in Table 0.1.

Table 0.1
SURPRISE MATRIX

	Uncertain	Bust	Boom	Moderate
Uncertain (Pragmatist)	No surprises.	Expected windfalls don't happen – Only Losses.	Unexpected runs of good luck.	Unexpected runs of good and bad luck.
Bust (Conservator)	Caution does not work.	No surprises.	Others prosper (especially Maximizers).	Others prosper (especially Managers).
Boom (Maximizer)	Skill is not rewarded.	Total collapse.	No surprises.	Partial Collapse.
Moderate (Manager)	Unpredictability.	Total collapse (when only partial was expected).	Competition.	No surprises.

Along the diagonal of the matrix (Table 0.1) the world is indeed the way it is expected to be — there are no surprises. To understand the surprises in the other 12 boxes, we contrast the strategy that seems sensible to each firm, with the responses the resulting tactics will provoke in each of the actual worlds.

- In the uncertain market, there is no discoverable pattern to the reactions of the marketplace to the company strategies. This is the world of financial uncertainty, when business activity and markets might turn abruptly. Maximizers, Conservators and Managers are all surprised by the lack of predictability of the uncertain market. Each had formed their own idea of what they were predicting and they all end up disappointed.
- In a bust, there is a discoverable order: the world is a vast negative-sum game. This is the world of the recession. Of course, Maximizers and Managers are surprised. The Maximizers thought that persistent losses would not happen and Managers are surprised by the magnitude of the losses. The Pragmatists are surprised when "correlations all go to one" and their preferred strategy of diversification fails to protect them.
- In a boom, the reverse happens — the world is a huge positive-sum game. This is when financial bubbles form. Managers and Conservators see the large gains of the Maximizers and are surprised that they can get away with that. Pragmatists see their own larger-than-expected gains and are surprised.
- In a moderate market, there is a discoverable order. This is the "normal" world. The Maximizers will be surprised that they underperform their expectations, while Conservators see the careful risk-taking of the Managers succeeding. Pragmatists are puzzled and surprised by the success of the orderly bean-counting Managers as well.

This process of changing risk attitudes typically takes two routes. First, individual managers will be surprised, as their unmet expectations wear away their convictions about how the world works. As these individuals then shift their risk attitudes, they will also shift their approach to their business and the risks that they're willing to take. If they are very perceptive and adaptable, they will change to a belief that aligns with the current environment and the process will begin again. If they are less adaptable and perceptive, they might shift to a different risk attitude that does not align with the environment. Their firms might then lurch along from one type of sub-optimal performance to another.

The second way that firms adapt is by changing leaders, most often when the firm has been spectacularly surprised. When the board reacts to a collapse — or even to a disappointment — by changing leaders, the new leader then faces the problem of shifting the prevailing risk attitude of the firm. Through a series of persuasions, orders, reorganizations, promotions, retirements and layoffs, the new leader will eventually get the firm's risk attitude to align with what they and the board want it to be. (See Section 3.1)

The third way that firms adapt is through an understanding of the entire four-fold paradigm with a risk attitude of Adaptor. (See Section 3.2) Those firms will seek to assess and identify the environment, then choose the approach to risk that best fits with that environment.

MODELING THE VARIETY OF DECISION MAKING

This project will work from the perspective described above (and in more detail in Appendix A), i.e., that management decision making in a firm will vary in complex patterns that systematically fit with the four environments, five risk attitudes and five strategies. There are many steps necessary to develop a full application of this perspective to modeling the variability of management decision making. This project undertakes the following steps:

Section 1: The Theory – takes us through the journey of these ideas from where they originated in anthropology to Enterprise Risk Management then finally to Institutional Evolutionary Economics (IEE), a complete theory of economics. A comparison of IEE to four other theories of economics is provided. Section 1 addresses the variety of decision making, for example, according to a strategy of neoclassical economics, or behavioral economics, evolutionary economics, institutional economics, ecological economics, and so on.

Section 2: An Application – shows how actual historical data for a group of 100 insurance companies can be mined to empirically develop a transition matrix which shows the frequencies of changes from any one risk attitude to another. This section provides a demonstration that the variability that is suggested by IEE can be found in the real world. And it also provides an example of how a practitioner can go about parameterizing a transition matrix from actual public data about insurance companies. Section 2 looks at the variability over time of the decision rules, for instance, Risk Steering being succeeded by Loss Controlling, then Risk Trading, and so on.

Section 3: The Model – control and systems theory is applied to modeling such variety and variability. Three tentative models of variability are p[resented. These models are cast in terms of the input output behavior of systems, of control theory. This involves the presumption that recursive time series analysis could be used to estimate the time varying parameters in any of the three models. The first of these three models proceeds from the idea of transition probability from Section 2. These transition probabilities take an enterprise from a previous decision strategy to a new decision strategy, one of the three others among the four basic strategies of risk coping. There is a prior and posterior probability of a strategy being good for the times based on working with what strategy is now, what the transition probabilities are, and what strategy could therefore be most probable next period. The second model is a control theory model, which also stems from Section 2. The third model is then a blended model.

Finally, Section 3 presents a Blueprint of the Adaptive Strategy. Plural Rationality has almost universally dealt with the four basic rationalities, four strategies and risk environments. Plural Rationality literature also mentions a fifth rationality. And that is what is now called the Adaptor. The adapter really has her or his eye on the long term, and is somehow standing above and observing what is going on among the other rationalities and trying to take care of the resilience of the company. The details of this strategy are a "Design for Resilience" for the long-term health of the enterprise.

Section 1: The Theory: Institutional Evolutionary Economics

1.1 WE ARE PLURALLY RATIONAL AND INHERENTLY RELATIONAL

Conventional diagnoses of the 2007/8 Global Financial Crisis see it as “abnormal”, and then resort to explanations (if you can call them that) in terms of “irrational exuberance”, “animal spirits”, “herding behavior”, “group-think” and so on. The prescription – “better regulation” – then follows automatically, as it has done after every such crisis, all the way back to Tulipmania 400 years ago. But if there are different seasons of risk, and if financial actors are able to latch onto different risk-handling strategies, each appropriate for one of those seasons and inappropriate for the others, then we have a different explanation: one in which there is no longer any place for abnormality. That is the approach we will be taking in this report: an approach which we call institutional evolutionary economics.

1.2 BEGIN WITH SOCIAL ANTHROPOLOGY

Our approach has its origins in social anthropology: specifically the cultural theory (or *theory of plural rationality*) that was pioneered by Dame Mary Douglas.[1] In fact, Gillian Tett (in a 2 August 2012 *Financial Times* article: “Anthropologists join Actuaries on Risk”) referred to it as “the anthropological approach”.[2] A good label, we feel, in that it helps distinguish our institutional assumptions from the essentially non-institutional (i.e. individual psychological) ones that characterize most economic theorizing: neoclassical economics, for instance, with its rational maximizers; behavioral economics with its individual actors falling short, in variously patterned ways, of what neoclassical economics demands of them; and Keynesian economics with its “fundamental psychological law” (that “men [sic] are disposed, as a rule and on the average, to increase their consumption as their incomes increase, but not by as much as the increase in their incomes” [Keynes 1936:96]). More specifically, our point of departure is not the familiar “individual” but the much less easily grasped pair of assumptions that are bound up in the slogan (and this chapter’s title): “we are plurally rational and inherently relational.”

First, people can consistently do very different things and yet be perfectly rational, given their very different convictions as to how the world is and people are. Hence, in contrast to the familiar DMUU (Decision Making Under Uncertainty), there is the notion of DMUCC (Decision Making Under Contradictory Certainties [Thompson and Warburton 1986]). The theory of plural rationality proposes a typology of four sets of convictions[3] -- *myths* (or social constructions) *of nature* – only one of which aligns with the “rational utility maximizer” assumed by neoclassical economics: that humans are self-seeking, and that nature is mean-reverting (i.e. can be relied on to “bounce back” after any perturbance).

Second, individuality, far from being something that is inherent in each of us (like our fingerprints, say), is something that, to a considerable extent, we get from our involvement with others. We discover our preferences by establishing our social relations. Since the theory of plural rationality proposes that there are just four forms of *social solidarity* (just four ways of binding ourselves to one another and in so doing

[1] “Plural rationality” is perhaps a better title in that “cultural theory”, as well as causing confusion with other (e.g. literary) theories that have adopted the same name, can too easily give the impression that it is culture that is doing the explaining (which, of course, is not at all the case). The two-volume *The Institutional Dynamics of Culture* (6 and Mars 2008), especially its introduction, is perhaps the best summary of this theory’s development and widespread application (mostly in fields other than financial risk).
[2] She was reporting on a joint keynote presentation she had made, together with Michael Thompson and Alice Underwood, at the IFoA’s (U.K. Institute and Faculty of Actuaries) Risk and Investment Conference in Leeds that year.
[3] The full typology, as we will be explaining is actually “four-plus-one” in that we need to allow for the Adaptor.

determining our relationship with nature),[4] there will always be four distinct and contending "models of the person" – *individualist*, *hierarchical*, *egalitarian* and *fatalist* – only one of which (the individualist) is countenanced by neoclassical economics (Douglas and Ney 1988). Put another way, the anthropological approach reveals the invalidity of that much relied-upon distinction between the individual and the institution. Indeed, it makes more sense to speak of the "dividual" (Marriott 1967), since we all move in and out of different solidarities in different parts of our lives: workplace and home, for instance.

One of us, Michael Thompson, recalls a drill-sergeant at Britain's Royal Military Academy Sandhurst, whose seven-year old son had been naughty. He had his wife march the young offender into the living-room in their married quarters where, the charge having been read out, he was duly sentenced to three nights early bed and a week's stoppage of bicycle. It was not a great success. The drill-sergeant's refusal to dividualize himself upset the harmony in his home and led to him becoming something of a figure-of-fun, among both the instructors and the officer cadets, in his workplace.

1.3 INSTITUTIONAL EVOLUTIONARY ECONOMICS: A NEW THEORY OF ECONOMICS

One of the eternal troubles with comparing theories, and putting them into competition with one another – which, of course, is what we are intent on doing – is that the proponents of those theories tend to be so immersed in their chosen ones – so institutionally embedded, that is – that they find it almost impossible to entertain the possibility that things might be otherwise. (See Section 3.1) As someone once said, "we don't know who first discovered water, but we can be sure it wasn't a fish". That is why we have begun by setting out our theory's two foundational assumptions and then contrasting them with those of other theories. However, since this is only the very tip of the assumptional iceberg, Table 1.1 summarizes what we see to be some of the key differences between some of the economic theories, our own among them, that are on offer.

[4] Four-plus-one, properly speaking, as is explained in the previous footnote. This is the generalized version of the definition of forms of social solidarity that is set out (in relation to climate change) in Rayner et al (1999:34).

Table 1.1
COMPARING FIVE THEORIES OF ECONOMICS

	Theories / Characteristics	Neoclassical Economics	Behavioral Economics	New Institutional Economics	Evolutionary Economics	Institutional Evolutionary Economics
1.	Rationalities	1	1	2*	2**	4-5
2.	The System	Simple	Simple	Simple	Complex	Complex
3.	Institutional Embeddedness***	No	No	Yes	No	Yes
4.	Increasing Returns: History Matters	No	No	No	Yes	Yes
5.	Equilibrium	Yes	Yes	Yes	No	No
6.	Technology Crucial	No	No	No	Yes	Yes
7.	Scarcity Crucial	Yes	Yes	Yes	No	No
8.	Emergent Behavior (Evolution)	No	No	No	Yes (Some)	Yes (More)
9.	Fit With Neuroscience	No	No	Sort of	No	Yes
10.	Ideas of Fairness	1	1-2	2	Not Clear	4-5
11.	Myths (Social Constructions) of Nature	No	No	No	No	Yes
12.	Allometric Relations (TIME-dynamics) Matter	No	No	Not Clear	Yes (in respect of scales of Time)	Yes

*As in the distinction between "substantive rationality" (the bottom line) and "procedural rationality" (who has the right to do what and to whom).

**Implicit, for instance, in the bifurcation – between "fundamentalists" and "chartists" – that emerges in the Santa Fe artificial stock market (Arthur 1995; Tayler 1995).

***The unquestioned assumption that people are rational utility maximizers, for instance, together with the similarly unquestioned assumption that Mother Nature can take anything that we throw at her, generates a *thought style* (Douglas 1996) that is very different from those that are generated by those who cleave to the other pairings of the myths of nature (row 11).

1.4 SOME THEORIES AND THEIR KEY DIFFERENCES

This is an incomplete list, of course. No Marxist theory, for instance, no Buddhist economics (as in Schumacher's [1973] *Small Is Beautiful*) and no Keynesian theory, but the interested reader might enjoy trying his or her hand at adding them in. Keynesian theory, for instance, seems to have much in common with the "new institutionalism" (e.g. Williamson 1975), in that it entertains two rationalities: those of the market and the hierarchy, thereby opening the way for the sort of government interventions that Hayek was so opposed to. Hayek, being more in the neoclassical camp, wanted the market to do everything (or rather, everything it could) but, even so, as Keynes famously pointed out, a line *has* to be drawn somewhere (see Thompson 2008a).

At this stage, one thing, we submit, is clear: our institutional evolutionary economics has much more in common with evolutionary economics – the rejection of equilibration, for instance, the centrality of technology, and the insistence that history matters (that small, random events cannot always be counted on to iron themselves out in the aggregate) – than it has with any of the others. Certainly, while the institutional embeddedness of Plural Rationality is indispensable to the development of the Adaptor strategy in Section 3, its discussion draws more heavily on the evolutionary nature of things. Time and the dynamic behavior of systems — including across scales of time, hence the evolutionary (as in the allometric relationships of the last row of Table 1.1) — are key to this novel Adaptor strategy.

Also evident in Table 1.1 is that there seems to be virtually no key differences between neoclassical economics and behavioral economics. This is perhaps surprising, given that the latter shows that people are simply incapable of doing what the former requires of them (Kahneman et al 1982). However, there is one rather crucial difference in that behavioral economics, by introducing a status difference between those who (contra the theory) are more capable of doing what neoclassical economics requires and those who are not, makes possible intervention by "nudging" (Thaler and Sunstein 2008). This, of course, takes things across from individualism to hierarchy, with the nudgers saving the nudgees from themselves: "wise guidance", as it is called.

We begin in clearly recognizable economic territory: the turbulent events of 2007/8 and mainstream economics' all-too-evident inability to answer the British Queen's question: "Why did nobody see it coming?". However, it is, as they say, an ill wind that blows nobody any good, and this spectacular and very public failure of orthodox economic theory has provided us with a wonderful opportunity to come up with something better. As we progressively open up these key differences – some, inevitably, in rather more detail than others – we set out what we see as the full answer to the Queen's question. Unsurprisingly, the resulting institutional evolutionary economics turns out to be very different from those theories (among them, the ones we list in Table 1.1) that were unable to provide Her Majesty with an explanation.

1.5 OUR APPROACH BY WAY OF ANTHROPOLOGY: BOTH SOCIAL ANTHROPOLOGY AND PHYSICAL, I.E. BIOLOGICAL, ANTHROPOLOGY

In contrast to the founding fathers of social thought (for example, Maine, Tönnies and Durkheim) all of whom fastened on dualistic schemes (for example, status/contract, *Gemeinschaft/Gesellschaft* and mechanical solidarity/organic solidarity), theorists of institutions now routinely invoke three (or four or five) different ways in which we bind ourselves to one another and, in so doing, determine our relationship with nature.[5] In other words, at least one more way of interacting has been added to the classic markets-and-hierarchies distinction: *community* (Etzioni 1988), for example, or *clubs* (Williamson 1975)[6] or *clans*

[5] For an account of the mismatches between these dualistic schemes see Thompson and Rayner (1998). For an unpacking of all the schemes – single, dualistic, threefold and fourfold – that are possible if there are in all four solidarities – there are 50 of them – see Thompson (2008b ch. 8).

[6] This may appear to contradict our Table 1.1, where we say that the new institutionalism entertains just two solidarities/rationalities. But Williamson's clubs, we have observed, "do not come from the same matrix, built out of the same dimensions as, markets and hierarchies" (Thompson et al 1990, p. 14). In consequence, his dynamics are "simple" (row 2, Table 1.1: the system): a back-and-forth between markets and hierarchies in response to upward – or downward – spiraling transaction costs.

(Ouchi 1980) or *collegiums* (Majone 1989) or *bonding social capital* (Szreter and Woolcock 2004) or *cliques* (Burt 1992) or, going a bit further back, *charisma* (Weber 1930).[7]

Proponents of the new institutional economics, in contrast to their political science and sociology colleagues, seem not to have moved on from two to three (or more) solidarities. Like Oxford's New College, they are now a bit long in the tooth: still back there with Ronald Coase's characterization of firms as islands of central planning (hierarchy in our terminology) in a sea of market relations (individualism in our terminology) and with Oliver Williamson's afore-mentioned dynamical back-and-forth, in which spiraling transaction costs lead to market failure and to the hierarchy then having to step in and set prices, with things going the other way in situations where the spiral is downwards (Coase 1937; Williamson 1975; see also Richter 2016). The one partial exception is Elinor Ostrom who, despite her explicit attachment to rational choice (and an accompanying aversion to plural rationality [see Ostrom and Ostrom 1997]), ended up with three (and implicitly four) distinct forms of behavior: "rational egoists", "conditional co-operators" and "willing punishers": fatalism, individualism and hierarchy, respectively (Ostrom 2000). In other words, institutional economics, at present, is insufficiently plural: it lacks what cyberneticians call the "requisite variety": that a control system (about which we will have much more to say in our Part 3) must contain as much variety as exists within that which it aspires to control (see Ashby 1968).

In this sort of institutional approach, we are arguing, it is the form of solidarity – the way of organizing, perceiving and justifying social relations – that is the unit of analysis, not the individual (row 3 – Institutional Embeddedness – in Table 1.1). Indeed, as we have already suggested, we really need to speak of “the dividual”, since a psycho-physiological entity may be expected to move in and out of different solidarities in different areas of his or her life (with our exceptional Sandhurst drill-sergeant proving the rule, as it were). Also, in going from the time-honored two to three (or four or five), these theorists have taken social systems from simplicity to complexity (row 2 – the System – in Table 1.1).[8]

What is very important for this approach in terms of plural rationality is that the sorts of neurological processes it requires of each of us – that he or she be able to internalize all of these rationalities, for instance, and then be able to switch from one to another in response to appropriate “cues” – not be physiologically impossible. Indeed, “very important” is understating it; if it turns out to be physiologically impossible then the theory itself is finished!

So, quite early on, we took the precaution of organizing a workshop – held in 2010, under the joint sponsorship of the Konrad Lorenz Institute for Evolution and Cognition Research (KLI) and the International Institute for Applied Systems Analysis (IIASA), and titled “The Human Brain and the Social Bond” – that brought together a wide range of scientists from these hitherto rather poorly connected social and natural science realms. To our great relief, we found that the neuroscientists were quite comfortable with this plural rationality framing. There was, they assured us, nothing physiologically impossible about it. Rather, it was the uni-rationality required by rational choice theory (be it in its neoclassical or behavioral economics form), along with the other extreme (in which rationalities proliferate towards infinity) that is required by post-modernism, that they had difficulty with (row 9 in Table 1.1: Fit With Neuroscience). So, taking a leaf out of the modern physicist’s book, we can hypothesize that, if this sort of “constrained pluralism” is possible, perhaps it is compulsory. And that, we have somewhat belatedly realized, is the deep hypothesis that underlies our institutional evolutionary economics. Since then, these somewhat tentative findings

[7] For an exhaustive overview, see Tilly (2005).

[8] In the mathematical sense of these terms; complex systems being indeterminate, unpredictable, non-equilibrating, sensitive to initial conditions and so on. For the policy implications of this shift from simplicity to complexity see Thompson and Trisoglio (1997).

have been much strengthened, thanks to some sustained joint work by social scientists and neuroscientists: social anthropology reconnected with physical (i.e. biological) anthropology as we have put it (see, in particular, Verweij et al 2015; Verweij and Damasio 2019).[9]

That there is one word – *system* – that recurs throughout all our discussion is far from accidental. Indeed, our entire framing and approach is in terms of systems: dynamical, and very often self-transforming, systems. This is hardly surprising, we concede, given that all of us are connected – some loosely, others rather tightly – to the International Institute for Applied Systems Analysis (IIASA): a think tank, housed in a Habsburg palace just south of Vienna, whose researchers strive to understand why, at times and in places, things – be they social, environmental or governance-related – do not go quite as swimmingly as they might.

[9] Over the years, in most universities, social and physical anthropology have drifted apart; at Oxford, for instance, they are housed in separate institutes. But they have stayed together at University College London, thanks in no small part to Mary Douglas' enthusiasm for both, exemplified by her support for Robert Turner who has had a distinguished career in both these components of the discipline. We mention this because we feel that our argument really cannot stand up without a foot in each: social anthropology and physical anthropology.

Section 2: An Example – Identifying the Rationalities in Insurance Firms

Plural Rationality theory says that we are situated within a complex adaptive world. We seek to understand the world, we choose a strategy based upon that understanding, our choice (as well as the choices of all others) of strategy has an impact upon the world and the world either continues upon its course or changes direction as our combined activities bring the world towards or pulls away from tipping points that thrust things into different regimes.

2.1 ACTUARIAL MODELS

When actuaries build models of the future, however, our strategy sometimes gets reflected as fixed in amber. Regardless of events, we project that any and all of the choices that management makes on a daily, weekly, monthly basis, especially the choices related to risk mitigation activities are made in the same way that they were made in the recent past. Not a believable prediction, but perhaps the best of the few choices that have been imagined.

For example, in Shang and Sethi[10] the management choice for setting a bonus is first defined as a fixed formula, and then occasionally modified to reflect certain more extreme situations in the environment.

We suspect, however, that an approach to modeling future management practices that includes likely variety of changing future environments (the exact variations that are at the foundation of our risk models) might produce significant differences in results, though at this point, we cannot predict whether those differences would expand or contract the variabilities that are the output of the models.

In U.S. insurance sector, the "underwriting cycle" is an oft observed phenomena that seems likely to be the result of variations in management decisions over time. Modeling of the underwriting cycle is proposed by Wang, Major, Pan and Leong[11] using a regime switching approach as well as in Yang et al (2016). This cycle has also been described in terms of the four rationalities of Plural Rationality by Ingram & Underwood.[12] You will see that these two approaches can be combined in Section 3.

Changes in management choices regarding risk management strategy and tactics may potentially have at least as powerful of an impact upon the modeled variability as management has the option to change those choices for the entire block of business at any time. These choices are seen to be impacted by the biases that were identified within Behavioral Economics literature by Shang.[13]

The claim of market value-based regimes to properly value options totally ignores valuing management's options to change their choices. Such choices include the degree and direction of durational mismatch that is targeted and permitted within an asset liability management system, the choices between the wide variety of reinsurance structures as well as the amount of risk retained and the maximum amount of reinsurance purchased (as well as the market appetite and price for all of those choices), the hedging goals for a variable annuity program (as well as the market appetite and price for different options) just to name three such possibilities.

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[10] Shang, K and Sethi, R Managing a With-Profit Portfolio using a Stochastic Approach, 2016 Presented at Asian Actuarial Conference.
[11] Wang, S Major, J Pan, H and Leong, J U.S. Property-Casualty: Underwriting cycle modeling and Risk Benchmarks. 2011 Variance.
[12] Ingram,D Underwood, A The Human Dynamics of the Insurance Cycle, 2010, Presented at ERM Symposium.
[13] Shang, K Optimal Timing of Risk Management, 2016, SOA Monograph.

This section will illustrate a first step in an approach to systematically model changes in management choices that is consistent with Plural Rationality theory and Institutional Evolutionary Economics.

2.2 MODELING CHOICES IN THE SURPRISE GAME

The Surprise Game is an agent-based model of a stylized economy within which 30 companies operate.[14] They each observe the environment, make judgments about their environments, choose strategies based upon those judgments and have an impact upon the environment. In this paper, we will be seeking to show how an actuary might mimic a part of that process to incorporate into a risk model.

In the Surprise Game, the choices are simulated by a set of transition probabilities. In many periods, for many of the companies, there is no urge to change strategy. But in some periods, there is a perceived disconnect between the company's prior judgment about the environment and the emerging experience in the actual environment.

As the game progresses companies will make choices according to their beliefs and will experience either success or disappointment. Individual companies will change their beliefs when they find themselves in a predefined situation reflecting some version of disappointment (or Surprise). The change in belief will follow the following transition probabilities. For a complete description of the definitions of the "Situations" please refer to the Ingram, Thompson and Underwood paper.[15]

Table 2.1
EXAMPLES OF TRANSITIONS WITH LIKELIHOODS

	PRAGMATIST	MANAGER	CONSERVATOR	MANAGER
Situation 1	25%	25%	25%	25%
Situation 2	33%	33%	33%	0
Situation 3	33%	33%	0	33%
Situation 4	0	33%	33%	33%
Situation 5	0	50%	0	50%
Situation 6	--------No Change--------			

This is what we are proposing for actuarial models of future management behaviors: that future choices of management may be made by people with similar goals and experiences and education as current (or recent past managers). Or they may be different people. And they may have different beliefs about the risk environment from current managers – beliefs that have been shaped by their experiences.[15] And those experiences will have been driven by the random variables of the risk model which express the changing environment.

Let's look at an example of this idea. We will start in a moderate environment for equity market risk. It may seem like the moderate environment predominates, but likely because of a survivorship bias. Businesses will tend to operate in situations where they can flourish.

With this perception of predominant Moderate environment, many businesses will operate with a Manager risk attitude and a Risk Steering approach to their risks.[16] If this company is a life insurer in the years prior

[14] Ingram, Taylor, Thompson Surprise, Surprise (2012) ASTIN Bulletin.
[15] Bush,E Ingram,D 2013 Collective Approaches to Risk in Business: An Introduction to Plural Rationality Theory. North American Actuarial Journal.
[16] See Ingram, Thompson, Underwood Rational Adaptation for ERM in a Changing Environment 2009 – 2013.

to the Financial Crisis, then a variable annuity product with enough extra guarantees would have looked completely reasonable.

2.3 EXAMPLE OF TRANSITIONS IN ACTUARIAL LITERATURE

The most common usage of transitions similar to the approach that we are examining is the Regime Switching approach such as that described by Hardy (2001). The two regimes of stock returns resemble the boom and bust approach to viewing business cycles (Yang et al 2016) which is found in the way that the National Bureau of Economic Research divides the business cycle between periods of Recession and Recovery.[17] In Freedland, Hardy, Till (2009) a Markov model is described where the transition probability from one regime to the other for time t depend upon the regime in time t-1. This is the approach that we take in the example below.

2.4 BUILDING A TRANSITION MATRIX FOR U.S. PROPERTY AND CASUALTY INSURANCE

We will now look at an example where we develop parameters for a four belief, four strategy, four environment model with parameters developed from actual insurer experiences during the 18-year period from 2001 to 2018. This period was chosen because of data availability on the SNL database. We will be working with statutory data from 100 of the largest mutual Insurers.

This period of time includes the tail end of the Dot Com bubble bursting, the 2005-2006 hurricane seasons, the 2008 financial crisis and the earthquakes of 2011. It also includes the favorable experience of many of the other years in that time period.

This example is intended to provide both a demonstration that activity consistent with the Institutional Evolutionary Economics and with Plural Rationality Theory can be found in an actual business situation and to also demonstrate an approach that can be applied to other sub sectors of businesses to develop transition matrices that more specifically apply to those sub sectors.

2.4.1 ASSIGNMENT OF A PROMINENT BELIEF

The actions of each of the 100 insurers can be classified as fitting with one or another of the four beliefs of IEE: Conservator, Manager, Maximizer and Pragmatist in each year. We will illustrate an approach to that classification that uses three separate aspects of observable company outcomes, assuming that the outcome for the company in any one year was broadly what they wanted. The three observations will be: Premium Growth, RBC Ratio and Common Stocks as percent of Surplus. In each case, we will look to separate the 100 companies into three groups with a high risk, medium risk and low risk group.

2.4.2 PREMIUM GROWTH

In the Insurance industry high growth is considered potentially risky for two reasons. First, the most common way to achieve high growth is to offer the insurance products at lower rates than the competition. This approach can easily lead to setting rates that are below the cost of the insurance (which would be the claims paid plus the expenses incurred by the insurer). Second, the insurance business is fundamentally

[17] NBER Business Cycle Dating Committee Determination of the February 2020 Peak in U.S. Economic Activity June 8, 2020. Is the most recent example.

about transferring the financial consequences of a risky situation from an insured to the insurer. Writing more insurance adds to the risk of the insurer.

The 18-year study period and 100 insurers provides 1800 data points for annual premium growth. When we examine those 1800 data points, we see the following distribution of growth rates by company by year (Table 2.2).

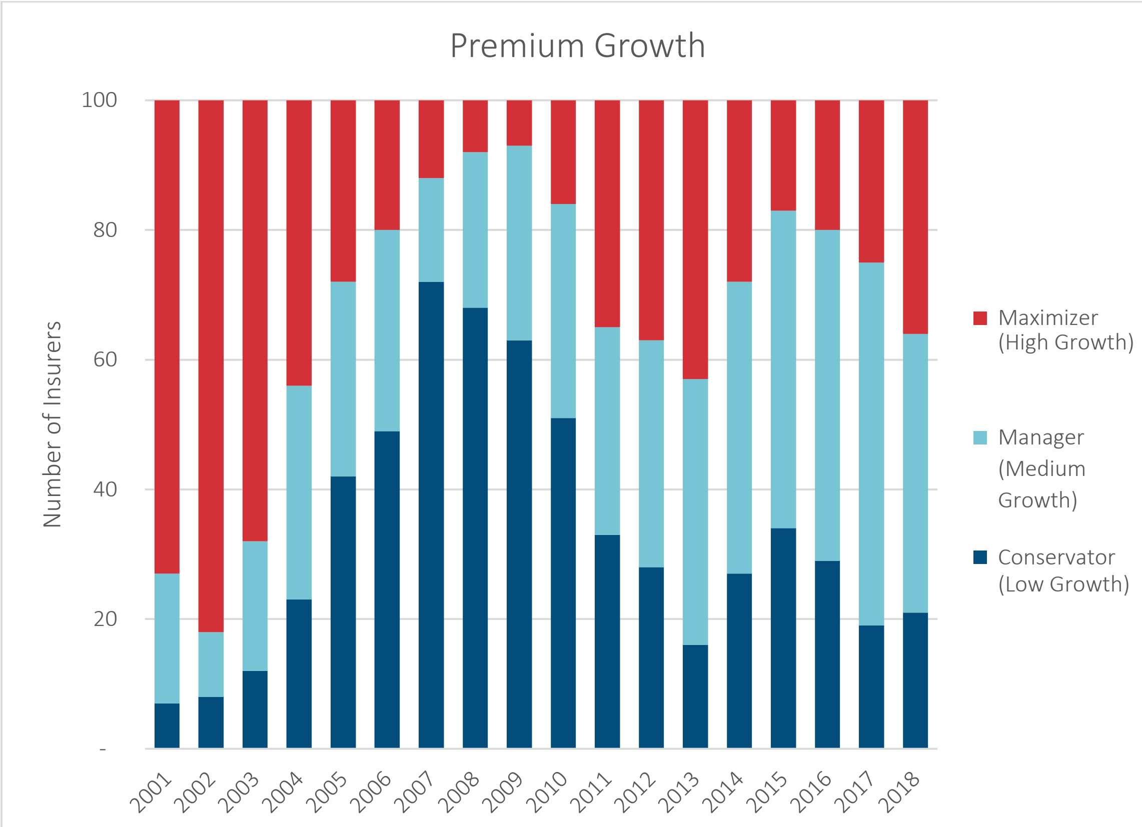
Table 2.2
ANNUAL PREMIUM GROWTH RATE

Percentile	Premium Growth Rate
1.0%	-20.4%
5.0%	-8.1%
10.0%	-4.2%
25.0%	0.3%
33.3%	**2.0%**
50.0%	4.8%
66.7%	**7.5%**
75.0%	9.6%
90.0%	16.1%
95.0%	22.2%
99.0%	38.9%
Max	91.7%

If we classify premium growth of below 2% as Low growth (a Conservator choice of growth rate), premium growth above 7.5% as High growth (a Maximizer choice) and in between as Medium growth (Manager), those break points do divide the data into even thirds and are conveniently also reasonable break points for the High, Medium, Low split as shown in Chart 2.1.

Chart 2.1

100 INSURERS GROUPED BY PREMIUM GROWTH RATE CATEGORY



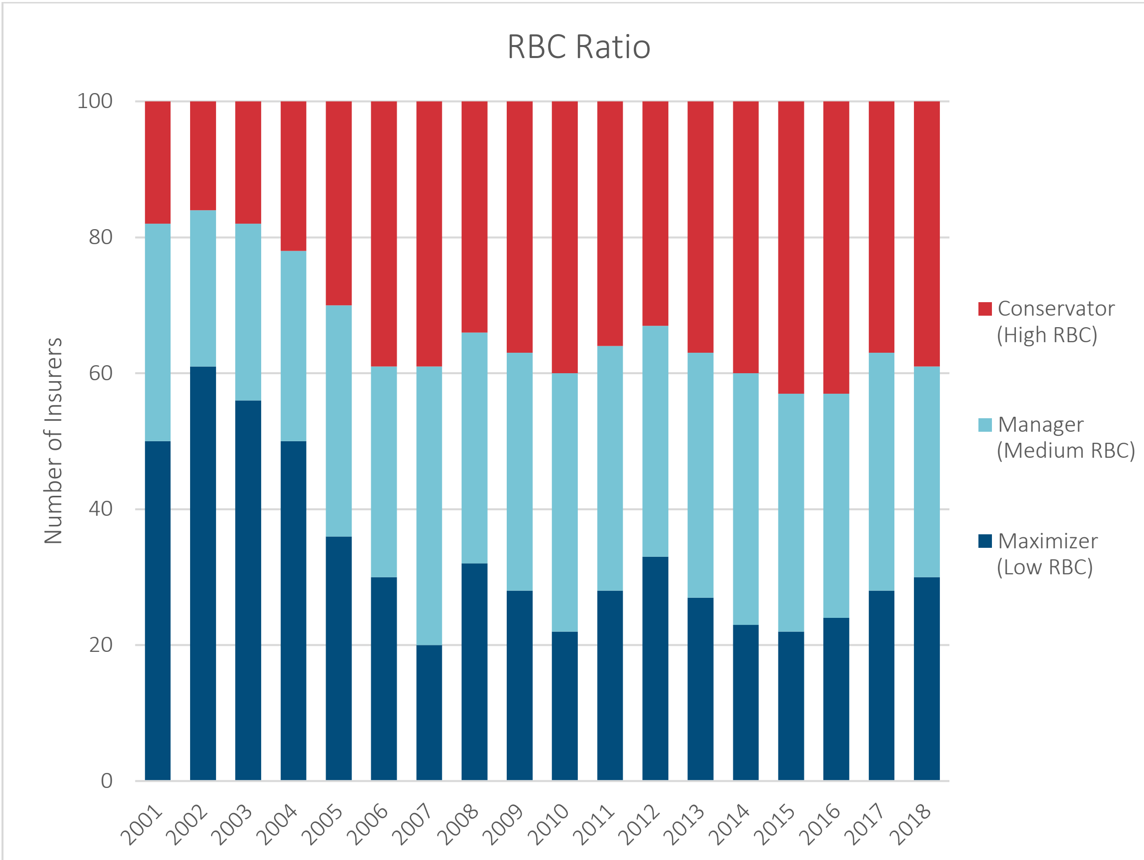
When we apply these labels to individual companies based upon their actual reported premium growth, we get an interesting display of the year-by-year dynamics of premium growth.

2.4.4 RISK BASED CAPITAL (RBC) RATIO

Risk Based Capital is the amount of capital required by the regulator that an insurer must hold and is based upon the various risks of the insurer. The RBC ratio is the surplus of the insurer divided by the RBC. A high RBC ratio indicates that an insurer has a high cushion against potential losses and would be consistent with the Conservator point of view and a low RBC ratio would be consistent with the Maximizer point of view, with Manager again in between. The distribution of the RBC ratios for each year for the 100 insurers can be seen in Appendix C Table C.1

One third of the results fall below 770% and one third above 1070%. As with the Premium Growth, we will use these values as the break points for dividing results between Conservator (above 1070%), Maximizer (below 770%) and Manager (between 770% and 1070%). This results in the annual distribution between the three groups shown in Chart 2.2.

Chart 2.2
100 INSURERS GROUPED BY RBC RATIO



2.4.5 COMMON STOCKS AS PERCENT OF SURPLUS

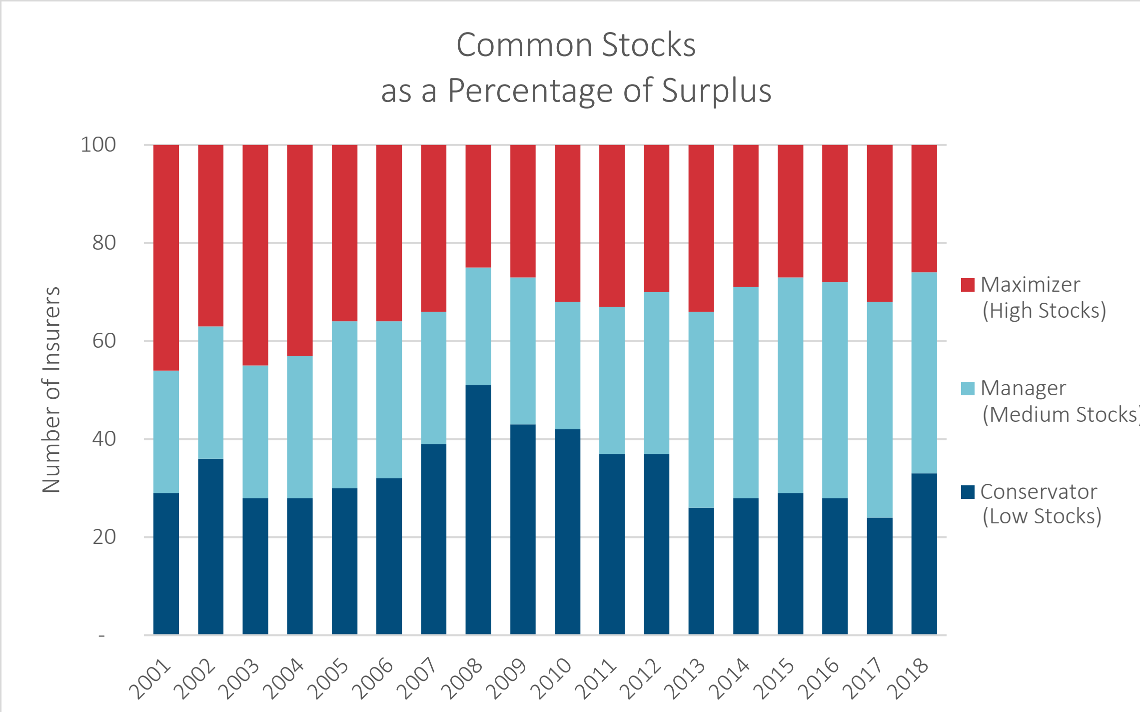
Common stocks are generally the most volatile investment that is made by insurers. In most cases, insurers will purchase bonds or other fixed income investments with funds that are being held for future claims payments and they will invest some portion of surplus in common stocks. A larger common stock holding compared to surplus would be higher risk and more consistent with the Maximizer point of view, and a smaller common stock holding as percent of surplus would be lower risk and consistent with the Conservator point of view, with Managers in between as usual.

The distribution of the common stocks as percentage of surplus can be seen in the Appendix C Table C.2.

And again, we will use the 33.3 percentile and 66.7 percentile values as our breakpoints with the results shown in Chart 2.3.

Chart 2.3

100 INSURERS GROUPED BY COMMON STOCK HOLDINGS AS A PERCENTAGE OF SURPLUS



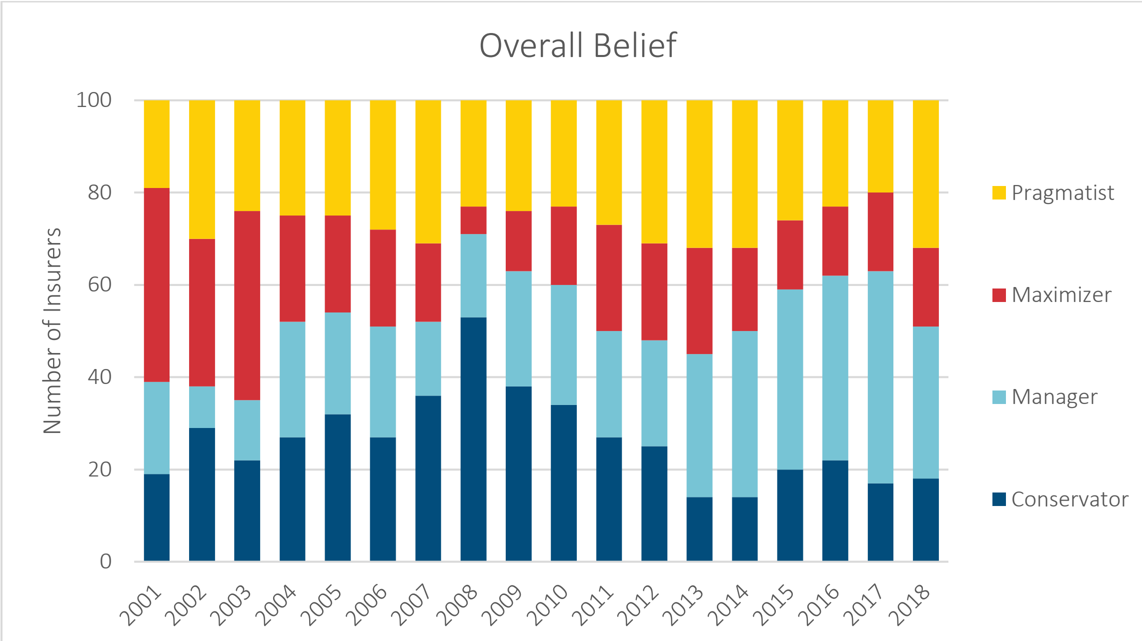
In this case, the ratio is changing due to both numerator and denominator effects. When there were large losses of value of common stocks, as in 2008, Surplus was depleted, and common stock values dropped even if no actions were taken.

2.4.6 ASSIGNING OVERALL BELIEF

Now we have three risk attitudes for each company for each year. We have coded the Conservator assignments as a 1, Manager 2 and Maximizer 3. The company/years observed give us a variety of combinations of 1, 2 and 3. See Table C.3 in Appendix C.

Now, we will make an assignment of overall belief. When all three assignments are the same, then the belief assignment is obvious. When two of the assignments are to one belief and the third is another, we will assign the belief of the two assignments. When all three beliefs are different, we will assign the Pragmatist belief (because the Pragmatist is not committed to any one course of action). This results in the following assignments of overall belief (And Appendix C Table C.4).

Chart 2.4
100 INSURERS GROUPED BY ASSIGNED OVERALL BELIEF



You notice that the Maximizers almost disappear in 2008 at the time of the financial crisis and in that year, at least, Conservators dominate as would be predicted by Plural Rationality Theory.

2.4.7 TRANSITION PROBABILITIES

The assignments leave us with a time series of assignments for each company. We can aggregate those series with a focus on the current assignment and the next assignment at each year. From that look, we can determine transition probabilities of a change in strategy. And it is our capacity to generate results such as those of Table 2.3 that gives us the prospect of developing the Transition Probability model of the variability in actuarial decision making in Section 3.

Table 2.3
TRANSITION MATRIX

		Future Year Belief			
		Pragmatist	**Conservator**	**Maximizer**	**Manager**
Current Year Belief	Pragmatist	46%	16%	13%	25%
	Conservator	16%	66%	4%	13%
	Maximizer	17%	7%	66%	10%
	Manager	26%	12%	6%	56%

This suggests that in most years, persisting with the same belief into the next year is most likely. With Conservator and Maximizer most persistent (66%), Manager somewhat less persistent (56%) and Pragmatist least persistent (46%).

Overall, insurers in this group are somewhat less likely to transition into Maximizer than the other three beliefs. That is to be expected from common knowledge about mutual insurers.

Table 2.4
TRANSITIONS OBSERVED

Belief in Year T+1	Count of Company-Years	Percentage
Conservator	455	27%
Manager	449	26%
Maximizer	340	20%
Pragmatist	456	27%
Total	1700	100%

A similar study of stock insurers would be expected to show a preference for Maximizer as that belief is thought to be the most closely aligned with "Shareholder Value Maximization" capitalization.

We can look at the variety of assigned belief of the 100 companies over the 18 years and we find that some insurers are assigned all four beliefs in one year or another; many insurers are assigned three of the four beliefs at one time or another; some insurers are assigned only two; and a few insurers earn the same assignment in all years.

Table 2.5
VARIETY OF BELIEFS OVER TIME

Pragmatist	Conservator	Maximizer	Manager	Number of Companies
	X	X	X	1
X		X		5
X	X	X		6
	X			3
X		X	X	14
	X		X	5
X	X	X	X	27
X	X		X	20
X			X	6
X	X			5
		X		5
		X	X	2

2.5 APPLICATION TO ACTUARIAL MODELS

This section will address two aspects of application of the above ideas to actuarial models: (1) What to do with a Transition Matrix and (2) How to develop a Transition Matrix for different types of organizations.

2.5.1 USING A TRANSITION MATRIX IN AN ACTUARIAL MODEL

The mechanical application of a transition matrix in an actuarial model is well described in the references cited in section 2.3 above. The issue that is unique to the application of IEE and Plural Rationalities in an actuarial model relates to what it might mean for the model to have transitioned from one belief to another. In the above development of the assignments of companies in particular years to beliefs, we used examples of possible approaches to business risk taking that were easily measured from public data relating to Premium Growth, Risk Based Capital Ratio, and Common Stock Holdings as a percentage of surplus.

An additional example for application of a Transition Matrix would be relating to investment strategy that is more detailed than just the ratio of Common Stocks to surplus that might be a major part of an actuarial model.

For this example, a generalized Transition Matrix will be used. (Section 2.5.2 discusses the development of a Transition Matrix for a specific situation). Under this generic transition matrix, Conservators and Maximizers (the most extreme beliefs) are expected to persist 65% of the time, while Pragmatist unbelief would persist less than half the time at 45%. Maximizers and Conservators are highly unlikely to transition from one to the other (5%), while all of the other transitions are higher but still low likelihood (in the 10% to 25% range).

Table 2.6
GENERALIZED TRANSITION MATRIX

		Future Year Belief			
		Pragmatist	**Conservator**	**Maximizer**	**Manager**
Current Year Belief	Pragmatist	45%	15%	15%	25%
	Conservator	15%	65%	5%	15%
	Maximizer	15%	5%	65%	15%
	Manager	25%	10%	5%	60%

In a model that does not reflect this variety of decision-making approaches, the strategy of the company is directly incorporated into the model. To reflect the idea of IEE into the model, there needs to be four strategies. One that aligns with each of the four beliefs.

For the investment portfolio model, there would be four investment strategies. Those might be something along the lines of the following:

Table 2.7
INVESTMENT STRATEGY EXAMPLES

Belief	Investment Strategy
Conservator	Selection of securities based upon avoidance of losses. Portfolio exceeds all regulatory and rating agency constraints. Fixed income investments restricted to higher investment grade highly liquid securities. Tight asset liability matching with frequent rebalancing. Immediate sale of securities that fall outside of these constraints. Otherwise, buy and hold. Equity investments restricted to value funds and amounts limited to the free surplus of the firm (i.e., funds in excess of those needed to satisfy accounting basis liabilities plus board approved additional funds held for security under stress.)
Maximizer	Selection of securities based upon maximization of returns. Portfolio satisfies all regulatory and rating agency constraints, if only at quarterly closing. Will usually hold maximum allowed risk assets of many types. May run a moderate asset liability mismatch of fixed income securities depending upon the slope of the yield curve.
Manager	Portfolio strategy based upon maximization of risk adjusted returns with level of risk also restricted by risk tolerance. Portfolio satisfies all regulatory and rating agency constraints. Careful asset liability and hedging strategies. Stock/Bond mix determined strategically to meet company objectives and adjusted tactically according to current market conditions. High reliance upon Investment Policy Statement.
Pragmatist	Usually favor highest return on investment. Few hard and fast rules for investment strategy – more guidelines that can be ignored in special circumstances. Equity positions are usually larger investments in promising companies – so equity returns will have less correlation with broad market returns. Less concerned with asset liability matching, except for institutional products. Less concerned with rating agency constraints. Will meet regulatory requirements.

More specific investment portfolio rules will need to be developed based upon each of those strategies.

These strategies may seem like exaggerated extremes. However, they are all real observed insurance company portfolio strategies. All of these extremes may not have recently existed at one company, except over a fairly long observation time frame. A modeler can look back over changes in investment strategies at a single company over ten or twenty years to see the range of actual variations and reflect those in the model.

Whenever there is a change of beliefs, the investment portfolio will not, at the time of that change, be very consistent with the new belief. Actual portfolio managers will often want to implement changes to the portfolio gradually over some period of time. To represent that in a model, transition rules are needed in addition to the portfolio strategies. The approach to transition could be simple and uniform for all situations. Something in the form of "the portfolio will be brought into compliance with the new strategy within three years."

Alternatively, a more complicated transition process might consider the different sensibilities of the four beliefs.

Table 2.8
INVESTMENT STRATEGY TRANSITION

New Belief	Transition Program
Conservator	Portfolio manager will sell all risk assets that exceed portfolio constraints within one year with the expectation that the riskiest positions would be closed the soonest. All new purchases will conform with new portfolio strategy. Illiquid investments will be divested within three years.
Maximizer	Apply portfolio strategy of return maximization to determine which parts of the portfolio should be sold first. Transition to full compliance with new strategy within one year.
Manager	Three-year transition. Assess risk adjusted returns of existing portfolio to determine what needs to be replaced and how fast. All new purchases will conform with new portfolio strategy.
Pragmatist	All new purchases will conform with new portfolio strategy. Assess largest positions for replacement of lower ROI. Transition as portfolio turns over except for lower ROI positions.

With something along these lines in place, the model can proceed with using the Transition Matrix to determine what change in belief, if any, happens in a year; and then what change in investment strategy results; and how the modeled portfolio manager reacts to the new strategy with the transition program.

2.5.2 WHEN THE GENERALIZED TRANSITION MATRIX DOESN'T FIT

There are several possible approaches to resolving situations where the generalized Transition Matrix does not fit well with past experience (or expected future experience) of changes in belief systems and therefore strategies.

Frequency of Changes
Some companies seem to stay with their strategies for much longer than the study of U.S. P&C mutual insurers would suggest. With the probabilities in the Transition Matrix, the likelihood of an insurer staying with the same belief (and therefore the same strategy) for even four years is 18% or less. A simple way to extend this was employed in the Surprise Game. There a company would not change beliefs/strategies for three years after making a change. This approach would allow for a "hold" period of two or more years depending upon the expected minimum duration of a new regime.

Severity of Beliefs
As was mentioned above, the examples for investment strategy are fairly extreme. The range of differences can be adjusted by defining strategies that are relatively more similar with leanings in the direction indicated by the beliefs. Small differences can make large differences in a long-term model.

Likelihood of Certain Beliefs

Other work[18] has suggested that Maximizer and Manager beliefs predominate among U.S. insurance executives and boards. While the above study of mutual insurers showed significant adherence to Conservator and Pragmatist aligned strategies, it is quite possible that expectations for a stockholder owned firm would be significantly less likely to transition into Conservator or Pragmatist beliefs for any length of time. In addition, mutual insurers would not be as likely to be dominated by a Maximizer belief as a Stockholder owned firm might. (Though it could be easily argued that some of the largest insurers are Mutual firms that are or at some point were run under a Maximizer consistent strategy.) An additional study of transitions among a homogenous set of insurers could be undertaken to determine a different transition Matrix for stockholder owned firms. That study could be similar to the study above or might use different parameters for determining the different implied beliefs. Including shareholder dividends in some way is an example of one such parameter.

[18] Underwood, Thompson, Ingram 2014.

Section 3: Systems Thinking, Social Anthropology, and Control Theory

3.1 INTRODUCTION

When actuaries build models, company strategy is conventionally accounted for as singular and fixed, immutable in time, while all else may vary. Regardless of events, we forecast that the choices management makes on a daily, weekly, or monthly basis, especially choices related to risk mitigation activities, are made in the same way as they have been made in the past — according, that is, to the same invariant, single decision *rule*. This is not actually a very plausible model for simulating company decision-making behavior, even though it may be the best of the few options for future strategy that have been imagined. Such a fixed-for-ever, singular decision rule does *not* avail itself of any (simulated future) data on company operating conditions as they evolve with time. The resulting (simulated) decision is not conditioned on actual experience in the vicinity of the current decision point; it does not take account of observations from the recent past and the present, nor of any foresight about the near future. Such a rule would not be deemed "dynamic", therefore, as in the "dynamic management actions" (DMA) life insurers are urged to model by Clark *et al* (2012). DMA in its turn, however, does not fully address modeling of either the "variety" of actuarial decision making or its "variability over time" as intended in the present project.

To provide context and clarification, imagine the following. Suppose the prevailing season of risk at some point in the (simulated) future is judged to be "Uncertain" (Appendix A), with the streams of data signaling the nature of the company's risk environment and its operating performance as those akin to the irregular volatility of the statistician's white-noise process. The company, in the light of the (simulated) sometime future data it is receiving, is correctly adhering to the "Diversification" decision strategy of the "Pragmatist" rationality of Enterprise Risk Management (ERM) (also Appendix A). If incorporated in a model, this, or any of the three other strategies for the three other seasons of risk, would each be a model of a dynamic management action (*sensu* Clark *et al*, 2012). In principle, four differently structured models of each risk-coping decision strategy should be incorporated into the overall systems model of the insurer's behavior. That alone would be a model of the *variety* in actuarial decision making, as futures are simulated, fanning out from the present time. At each decision point in time, four possible ways of making the decision — four strategy-decision rules — would be expressed in the model. Only one of the four, however, would be the right rule for the current season of risk.

Suppose now, however, that something not immediately obvious in the current and past data (of the hypothetical future) is beginning to shift qualitatively, subtly but surely. We would say that the season of risk is on the cusp of a transition, to "Moderate", or "Bust", or "Boom"; and that the rationality of the company's decision strategy should accordingly change qualitatively, to "Risk Steering", or "Loss Controlling", or "Risk Trading". Yet how should the company apprehend the imminence or actuality of the risk transition? Having somehow done so, how then does the company diagnose and duly categorize the newly arrived season of risk? And, to go yet further — to go thus to the core of our project — given the *correctly* diagnosed shift, how could we model and simulate the way in which this switch takes place: the swapping out of one risk-coping autopilot (one decision rule) for another?

That indeed is the challenge we have set ourselves, in particular, here in Section 3. Could we, accordingly, come up with better models, heuristic or mathematical, of how company strategy, i.e., company decision rules themselves, may change over time? In this, modeling the *variability* of decision making over time (as just illustrated) is tantamount to modeling the *variety* of decision making at any single instant in time. For at one and the same point in time different groups of company employees and stakeholders will adopt quite different stances on the purpose of the decision and have quite different attitudes towards coping with the associated risks. There will always be those in the company who maintain, even insist, that

Diversification, or Risk Steering, Loss Controlling, or Risk Trading is right for the times: *the* one and only correct decision rule for today (and forever). Such a plurality of stances and risk attitudes is observed empirically (Thompson, 2018), is inherent in Cultural Theory and plural rationality (Thompson *et al*, 1990), and is now to be accommodated in some manner in a model.

In Section 1, we have seen how the discipline of social anthropology (Thompson *et al*, 1990; Thompson, 2008) has been brought to bear on our challenge of modeling the variety of decision making. In Section 2, actuarial science and practice, as expressed previously in *InsuranceERM* (2009-13), have been applied to our core challenge. Section 1, we might therefore observe, was about the *variety* of decision making, for example, according to a strategy of neoclassical economics, or behavioral economics, evolutionary economics, institutional economics, ecological economics, and so on. Section 2 was about the *variability* over time of the decision rules, for instance, Risk Steering being succeeded by Loss Controlling, then Risk Trading, and so on. In the present section, we apply control and systems theory to modeling such variety and variability. In the yet wider picture, this third section of our paper draws its motivation in significant part from the recent (UK) Institute and Faculty of Actuaries' report on "Economic Thought and Actuarial Practice" (Clacher, 2019). In sum, therefore, we consider our entire project to have been an exercise in cross-disciplinary Systems Thinking.

3.1.1 ORGANIZATION OF SECTION 3

We now present in summary the results of our research from this third and last part of the project. Section 3.2 focuses on new results concerning the *modeling* of actuarial decision making for Rational Adaptability (RA) in ERM. Such modeling, and the supporting evidence it may generate for decision making in practice, calls upon a fifth rationality from Plural Rationality (PR), which we shall refer to as the Adaptor rationality-*cum*-strategy. This is a significant and novel addition to all our previous studies. Accordingly, a first blueprint for the Adaptor strategy is presented and elaborated in Section 3.3.

This final part of our project is cast within the logical and theoretical framework of Institutional Evolutionary Economics (in Section 1 above) and subsequently shaped in significant part by the empirical statistical results of the second component of our project (in Section 2 above). Two of the present (third) component's three prototypical models of variability in actuarial decision making are inspired by the results of Section 2. Beyond that, this final part contributes new developments to the two foregoing parts of our report. They are essentially and distinctively drawn from the reasoning of control theory, especially in respect of the Adaptor strategy. The following caution is therefore vital: Although contact with control theory usually results in the rapid resort to some quite complicated mathematical sophistication,[19] such is emphatically *not* our objective in any of our research.

3.2 MODELS FOR DECISION-MAKING STRATEGIES

To a not-insignificant extent what is novel about the results of this final part of our project is a perhaps surprising combination (and subsequent extension) of two hitherto completely separate lines of original enquiry, one dating from as far back as the 1960s (Benjamin, 1982), the other from the 1980s (Thompson, 1982). Surprisingly fused thus herein, these two original pillars are, first, the seminal combination of control theory with actuarial science, which is due to Balzer and Benjamin (1980) and Balzer (1982) (of which the

[19] The London School of Economics, for instance, has a Financial Mathematics and Control Theory Research group (http://www.lse.ac.uk/Mathematics/Research/Financial-Mathematics-and-Control-Theory). See also the Wikipedia entry for Stochastic Control, with even a separate sub-section addressing applications thereof specifically in finance: https://en.wikipedia.org/wiki/Stochastic_control#In_finance.

DMA of Clark *et al* (2012) is a contemporary manifestation); and, second, the fifth rationality of PR, which was originally designated the rationality of the hermit (Thompson, 1982; Thompson *et al*, 1990), but will now in this project be referred to as the Adaptor (Appendix A). The first pillar of our approach in the present section, being a matter of control theory, addresses *variability* over time in a decision strategy; the second, a matter of social anthropology and, in particular, Cultural Theory (PR), addresses plurality in the *variety* of decision making.

To the foregoing combination, a third essential ingredient must be added in order to achieve the new results shortly to be summarized. Its provenance lies in the early years of modern control theory, developing, as it was, at the turn of the 1960s/70s. Specifically, this is the presumption that all models may be populated with time-varying parameters (coefficients), whose variations with time may be estimated (in real-time, in principle) by the recursive algorithms of filtering theory and time-series analysis (Jazwinski, 1970; Young, 1984; Beck, 2002; Lin and Beck, 2012). To single these parameters out, because they are so fundamental, we shall write them as $\boldsymbol{\alpha}(T)$, wherein the argument of time T denotes variations with "macro" or "slow" time over (in general) the longer term, of typically the several quarters, years, perhaps even decades, over which seasons of risk prevail. This $\boldsymbol{\alpha}(T)$ device animates the role of the Adaptor in the modeling of Section 3.2 and brings us to the culmination of this third section of our project, the blueprint of the Adaptor's strategy in Section 3.3.[20]

If there is to be a practical implementation of the Adaptor strategy, as something necessarily *apart* from all the other four risk-coping strategies, it must address the following challenges: (i) be able to diagnose correctly the prevailing season of risk and check that actual company decision-making strategy is consistent with it; (ii) be able to apprehend at the very earliest juncture a qualitative change in the season of risk and — even more difficult — diagnose to what season the company's operating environment is shifting; and (iii) concern itself in earnest with infusing and supporting resilience in the composition and behavior of the "social" and "material" worlds of the company.

3.2.1 THE BARE NECESSITIES OF SOME PRINCIPLES OF CONTROL ENGINEERING

Before visualizing the logic of Rational Adaptation (RA), hence why and how we develop our models of variability in actuarial decision making, a minimal grasp must be acquired of what exactly control engineering is and what exactly it does. Again, we emphasize that the importance of our providing this basic grasp resides in the concepts and principles underlying control theory, not its mathematical fineries. So important is this basic grasp of control engineering to what follows, we choose not to relegate its presentation to an appendix.

At bottom, control engineering seeks to re-engineer how a system behaves over time; it seeks to re-engineer the system's dynamics. In particular, it takes the system's dynamic behavior as is and then re-engineers it so that it is more to "our" liking. It is as the difference between the comfort and smoothness of flight in an aircraft with control and the discomfort of flight in an aircraft without such highly controlled

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[20] When the present project was proposed (in December 2018), it was presented as the second of three inter-related projects. The need to develop an Adaptor strategy is the final recommendation of our precursor project for the AFIR-ERM Section of the IAA-AAI (Beck *et al*, 2020). The closure of the present project, in Section 3.3.4 specifically, anticipates what should be the subject of our third project (currently under discussion with the U.K. IFoA).

dynamics. In general, of course, and in its natural domains of application, control theory would not recognize any social plurality about the "our".

The controller in control engineering is a form of automated decision making. It may be intended to serve two purposes, known in the jargon as solutions to the "load" problem and the "regulator" problem. The latter seeks to transfer the state of the system from one performance condition at a start time to another state (condition) at a future end time. We might conceive of solutions to the regulator problem as being conceptually akin to getting the plane off the runway and transferring it with comfort (smoothly) to a cruise altitude at 10km. Solutions to the load problem keep the behavior of the system where and how we want it at all times (to "our" liking indeed), come what may, whatever untoward and unknown disturbances may buffet the plane. In this sense a controller may be designed primarily for "disturbance rejection".

Significantly, the automation of decision making arose historically as the human brain of the operator was confronted with the dynamic behavior of ever faster, bigger machinery delivering products designed to ever finer margins of tolerance against inadequacy and failure. The brain simply could not reason through any divergence between the observed actual performance of the system and its desired performance sufficiently quickly to determine appropriate corrective action and then implement it in a timely manner. And since speed of response was becoming of the essence, design of the automated decision-making scheme became dominated by a re-engineering emphasizing the need to expedite return to desired performance as quickly as possible. The trouble is, most ways of achieving such re-engineering bring with them increasingly oscillatory (bouncy, bumpy) transient behavior, and even eventually instability in the system's controlled behavior. In other words, whereas without control, the behavior of the system might not have been to our liking, re-engineering it to bring things around to our liking is bounded by that very control inducing deeply undesirable instability (though others might conceivably welcome exactly that for some systems).

Historically too, as "classical" control gave way to "modern" control in the 1960's, so arose the fixation in control theory on finding *optimal* solutions to the load and regulator problems. Moreover, given suitable assumptions about the statistical nature of the disturbances to which the system would be subject and a model of the system's responses to those disturbances, it became possible to answer this question (as a regulator problem): what would be an optimal sequence of decisions for each of the decision steps (marked in fast, micro time t) between the start (now) and desired terminal (end) future state of the system well out into macro time T (perhaps even beyond)?

One crucial further feature emerged with modern control theory. Computers were facilitating the mobilization and embedding of mathematical models of the system's dynamic behavior *within* the control schemes determining the decisions and actions to be implemented; and the computational devices embodying the resulting controllers were themselves being incorporated within the object of the system itself. It was accepted that the necessarily "minimalist" models could never be anything more than rather crude approximations of the system's actual dynamic behavior. They had to be minimalist for reasons of limited computational capacity. Crucially, therefore, the proposition arose that all models could (and should) be populated by time-varying parameters, by our $\boldsymbol{\alpha}(T)$. Indeed, as with all aircraft, and quintessentially so with guided missiles, the *structure* of the dynamics of the system is itself necessarily changing over time. Fuel is being expended, such that between departing from and returning to the ground the mass of the system is never constant, hence the essential structure of its dynamic behavior in response to any disturbance impinging upon it will inevitably change over the relatively longer term of T. Thus, a buffet of the craft half-way into the flight that is identical to an earlier buffet will evoke a different uncontrolled response to the earlier uncontrolled response. Given such structural change, the control rule would need to be adapted over time: variability upon variability in decision making, we might say. A strategy for changing strategy was needed. By tracking (estimating) the $\boldsymbol{\alpha}(T)$ minute-by-minute, the model would continue to provide the controller with its best current snapshot at the current decision-point *t* of the (ever-changing) structure of the dynamics needed to inform the decision rule of the controller. If collected together, the sequence of snapshots at each *t* in micro time would constitute a film (motion picture) of the evolution of the system from its beginning structure to its terminating structure.

If the familiarity of flight in an aircraft assists the reader in understanding some of the basic, generic principles of control engineering, the metaphor will have served its purpose. The principles are about the problems and solutions to decision making: whether for achieving "our liking" in respect of flight or coping with risk and other operating challenges (to "our" liking) in an insurance company.

Feedback Control
Figure 3.1 is cast in terms of classical control system block diagrams. Shortly, the same will be used to visualize the logic of Rational Adaptation, as a stepping stone *en route* to expression of our models of variability in actuarial decision making. More immediately, Figure 3.1 explains how the fundamental principle of feedback control — as a control rule; as a decision-making rule; as a decision strategy — enables an insurance company to "get" what it "wants", as opposed to merely getting what it "gets" come what may. Figure 3.1 takes us visually from an uncontrolled "open-loop" system (Figure 3.1(a)), in which there is no control (no intervening decisions), to a controlled "closed-loop" system (Figure 3.1(c)), with this latter opened up for closer scrutiny of its parts in Figure 3.1(b). The transformation wrought by the re-engineering principle of feedback is therefore that of enabling the company to get what it wants (Figure 3.1(c)) instead of just getting what it gets (Figure 3.1(a)).

Figure 3.1
FUNDAMENTAL PRINCIPLE OF FEEDBACK CONTROL*

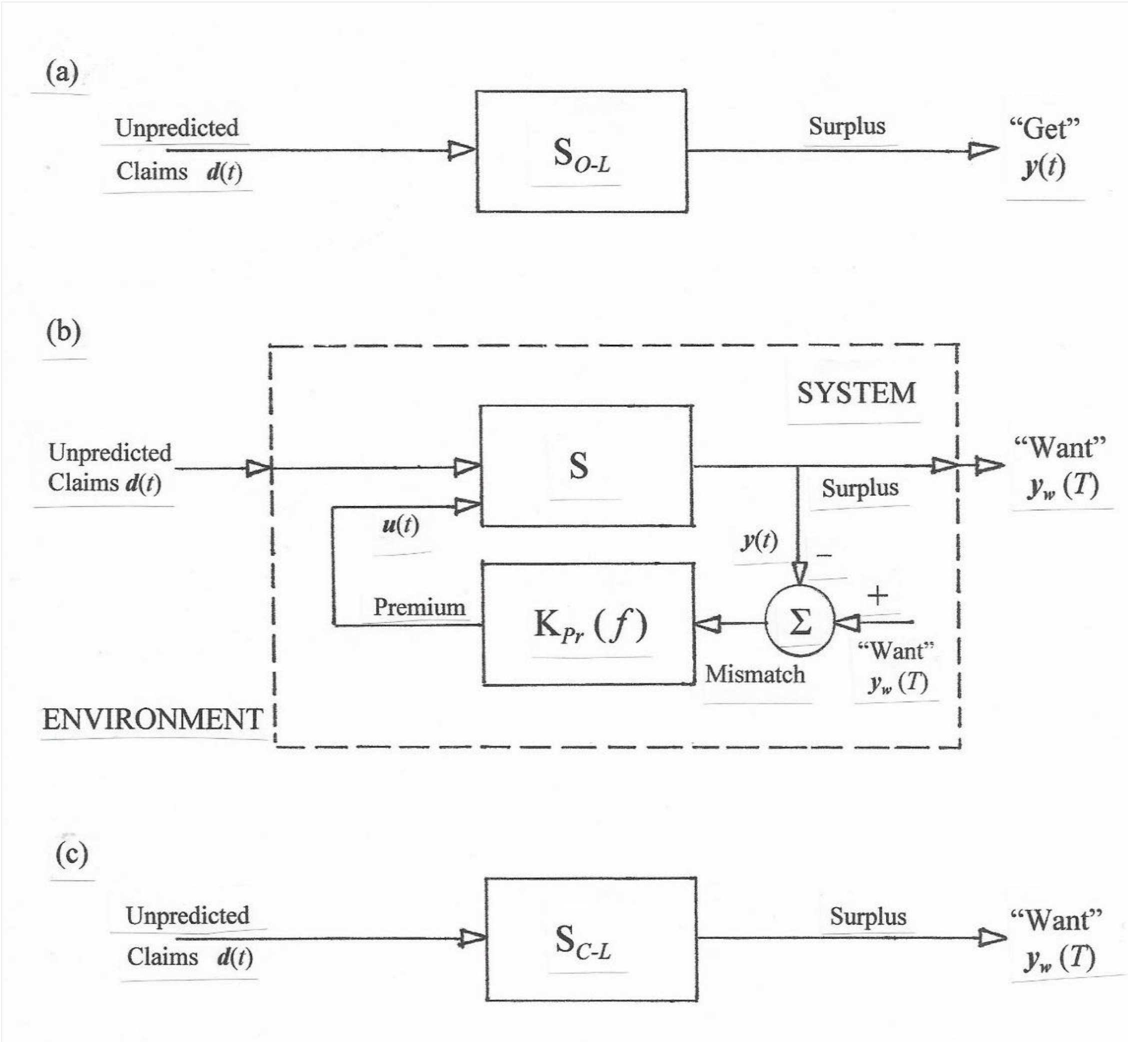

*Figure 3.1 The fundamental principle of feedback control: How to transform company behavior from getting what it "gets" (in (a)) to getting what it "wants", come what may (in (c)). The inner workings of feedback (in (b)): showing the System *versus* the system's Environment i.e., everything other than the System, including, in particular, the company risk environment; the S block for the company's non-executive processing operations; and the decision-making (executive) K block.

To grasp the essence of the transformation we need the exposed detail of Figure 3.1(b) and some accompanying algebraic notation. Looking at Figure 3.1(a), we label the incoming, input stream of disturbances impinging on the company as ***d***(*t*). Formally, we may now note that argument *t* here tags variations of the disturbances over the relatively short-term of micro or quick time; thus, to complement the already introduced *T* for macro time. Micro time *t* signifies higher-frequency variations over days and weeks, perhaps months; macro time *T* signifies lower-frequency variations over quarters and years, in general. The disturbances ***d***(*t*) in Figure 3.1 were taken to be the unpredicted claims in the original treatment of Balzer and Benjamin (1980), who referred to problems of instability in setting premium rates in an insurer operating a profit/loss-sharing scheme for one of its products. The block for the system "S" symbolizes the operational procedures the insurer employs to convert the incoming unpredicted claims into the outgoing cash surplus (deficit) responses ***y***(*t*). In the uncontrolled system of Figure 3.1(a), where S_{OL} signals the open-loop uncontrolled behavior of the system, the surplus the company "gets" is simply

$\boldsymbol{y}(t)$. Whatever the pattern of buffeting of the incoming claims, the insurer's output performance will similarly bump about.

Of course, what the company really "wants" is to have its operational performance be to its liking, i.e., to conform as closely as possible to what it wants of its surplus, $\boldsymbol{y_w}(T)$. This "want" is portrayed as the output from the closed-loop controlled system (S_{CL}) behavior in Figure 3.1(c). Significantly, these wants are presumed not to change quickly with time, but slowly. Hence their argument is slow macro time T, as opposed to fast micro time t. In the case of Rational Adaptation (as discussed later), company wants are assumed not to change during any one season of risk ("wants" prevail unchanged for each decision point t within that season) but to change abruptly as the season turns, which we would label as season T−1 (Moderate, for example) changing to season T (Boom, for example). There is, as we have said, a kind of swapping out of one autopilot and a swapping in of another.

Coming now to the heart of the matter of the re-engineering that achieves the transformation from Figure 3.1(a) to Figure 3.1(c), let us examine Figure 3.1(b) more closely. Two blocks appear in the diagram: the S block, which denotes the corpus of company operations previously present in the uncontrolled situation of Figure 3.1(a); and the controller "K" block, in which the notation K_{Pr} and f appear. Here, subscript Pr refers to the decision that sets the premium (price) of the company's product, which goes all the way back to the specifics of the seminal study of Balzer and Benjamin (1980). Symbol f denotes what is at the very heart of the matter for us: the company's decision-making strategy; the control rule that is to be modeled as proposed below (and defined later as a Group III type of model, in Section 3.2.2); the control rule that is subject to variability over time, i.e., from one season of risk to another.

How the principle of feedback control works is the subject of Figure 3.1(b). But first, note how both the S and K blocks comprise the "System" and all else that surrounds the "System" is its "Environment". The two blocks are the operational processing procedures (S) of the company together with the decision-making (K) that sets the product premium rate. Just to the right of the K block, we see what is called in control engineering a "summation junction" (denoted Σ), or better "comparator junction" here. It compares the two incoming signals one to another and, noting their respective signs, generates an outgoing signal. In Figure 3.1(b) the surplus the company is currently getting, $\boldsymbol{y}(t)$, is compared with what it wants, $\boldsymbol{y_w}$ (where we have removed the argument T for simplicity) to give thus the mismatch between the two, i.e., $\boldsymbol{y_w} - \boldsymbol{y}(t)$, which is fed into the decision block (K). Duly manipulated by the decision rule, i.e., function f, decision $\boldsymbol{u}(t)$ emerges as the selected premium applied as a second input to the operational processing block S. The negative sign attaching to the company's current output $\boldsymbol{y}(t)$ in the mismatch defines the feedback as (stabilizing) "negative feedback". Accordingly, if actual surplus is falling short of what the company wants, the premium rate will be increased (and vice versa).

The supreme success of the principle of feedback control is that it enables the company to get what it wants consistently, irrespective of how well or poorly the behavior of the system (S) is known (which knowledge will be seen to be typified by a model of the Group II category soon to be introduced in Section 3.2.2), and irrespective of the uncertainty attaching to the sequence of unpredicted claims $\boldsymbol{d}(t)$, knowledge of whose patterns of variation will be seen to be the subject of a Group I model below. If much is known about these two categories of knowledge, such that their corresponding Group I and II models are subject to relatively little uncertainty, wondrous things (arguably) might be conceived of for the design of the decision strategy f, *ergo* the (for us) core Group III class of model for the decision (K) block in Figure 3.1(b). For instance, we may come up with a (so called) model-based predictive form of control, which could steer the insurer's fortunes (output $\boldsymbol{y}(t)$) all the way from where they are now (today) to where the company CEO wants them to be several quarters, if not years, into the future — and all in accordance with a predetermined sequence of product prices ***u***(*t*) for *t* spanning from the decision for today to the decision years hence, one decision step prior to the future desired end-state.[21]

Finally, the cross-disciplinary limitation of Figure 3.1, if this is what it is, resides in the very fact of its being grounded in control theory, wherein input-output (cause-effect) models are generally essential and the custom. This, we recognize, may not necessarily be the case in the disciplines of modeling more familiar in actuarial science, such as Statistics, for instance.

3.2.2 THE STRATEGY OF THE ADAPTOR RATIONALITY: AS QUITE APART FROM THE DECISION STRATEGIES OF THE BASIC 4 RATIONALITIES

Conventionally, according to Plural Rationality in ERM (Appendix A), *each* of the Basic 4 risk-coping strategies amounts — in the phrasing of control theory and when inserted into the controller K block of Figure 3.1(b) — to a time-invariant autopilot for the company. Put another way, there can be four versions of Figure 3.1(b), one for each distinctive "style" of risk-coping; four functional forms (or models) for the decision strategy *f* in the decision block. As the seasons of risk come and go, therefore, there is *variability* about the actuarial decision making, as the strategy (*f*) of the Conservator, say, is switched to that of the Maximizer, and so on. The switch is discrete, technically from one decision period to the next, such that the variability of decision strategy to be modeled is quite special. We note therefore that our four models (one for each of the Basic 4 decision strategies (*f* 's)) should in theory have no need of the device of time-varying parameters **α**(*T*), since over any given season the **α** in each such model of each *f* should not vary with micro time *t*.

The elementary simplicity of Figure 3.1, however, has served its purpose. To embark now on contemplating and reasoning about the (fifth) decision strategy of the Adaptor, within the context of Rational Adaptation, requires the graduated complication of Figure 3.2. It is time too to introduce the classes of models (Groups I, II, and III) and clarify their distinctions with respect to Figure 3.2. The composition of Figure 3.2 is based on the logic of the agent-based model of the Surprise Game as originally used to develop and explore Rational Adaptability (Ingram *et al*, 2012). Here, however, the essence of the simulation has been simplified somewhat for present purposes.

The first thing to observe about Figure 3.2 is the way in which the "System" has been structured as two segments, of "Adaptation" and "Strategy". In terms of its logic, the lower Strategy segment is essentially identical to the simple feedback control scheme of Figure 3.1(b). It has the recognizable S block, comparator junction, and K block. The Adaptation segment stands apart, above. But the insurer content of the Strategy segment differs from that of Figure 3.1(b). It is configured according to what we shall call the "reserving" decision process of an insurer in the controller (K) block.[22] Mismatches between what the company is currently getting for its cash surplus and what it wants to achieve in the current season of risk are fed into the decision (K) block, from which duly emanate the (reserving) decisions ***u***(*t*) applied to the company operational procedures for husbanding its assets in the S block.

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[21] We surmise that such is the principle underlying procedures akin to the Black-Scholes formula for pricing virtual assets (today) given a desired goal for the asset owner several quarters and years hence.

[22] Since this word (reserving) is open to several particular interpretations in actuarial science, it is being used herein as follows: the decision exiting the K block is that of either putting a sum of money aside by investing it in some form of savings asset or of taking it out of the asset.

Figure 3.2
RATIONAL ADAPTABILITY IN ERM*

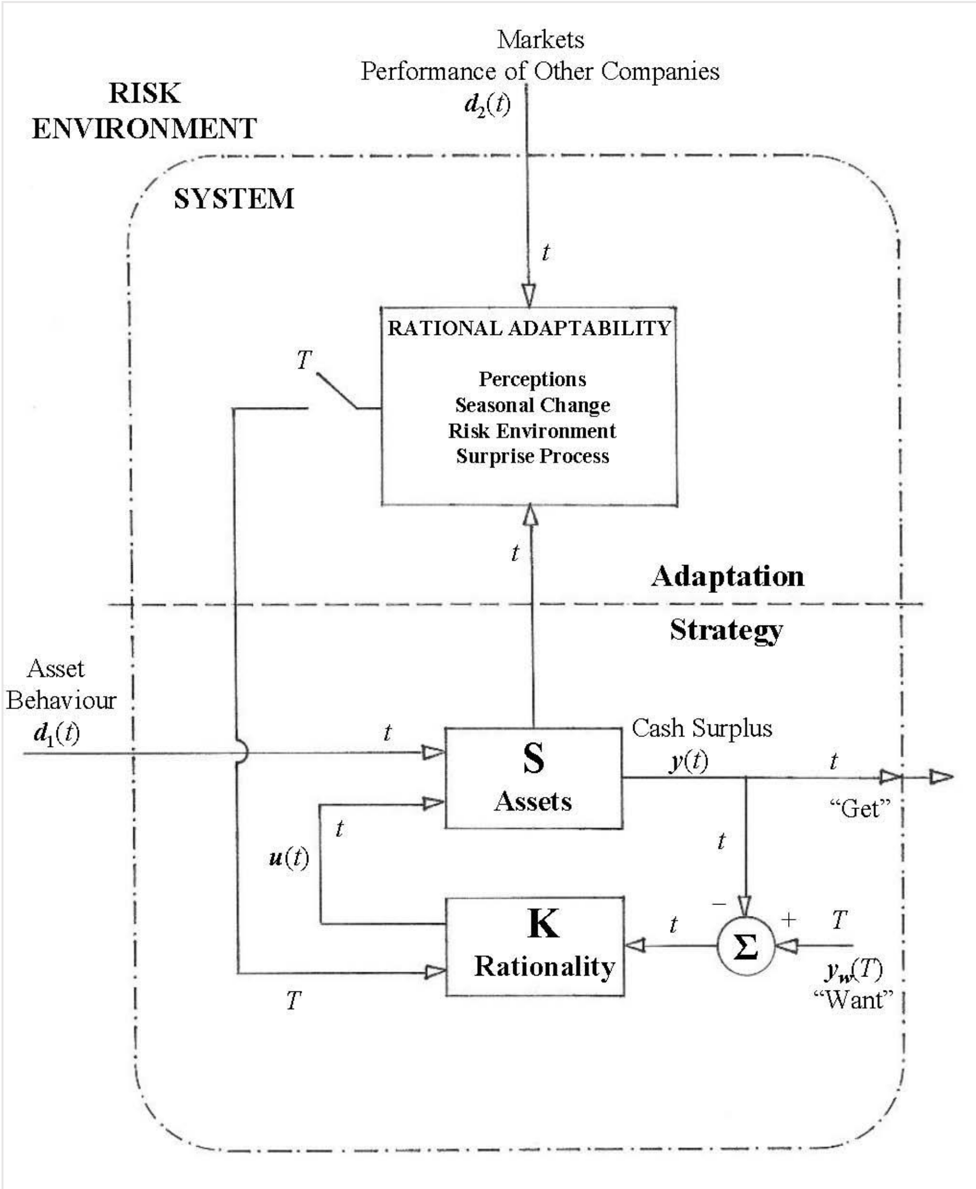

*Figure 3.2 Control-systems block diagram for Rational Adaptability in ERM, as a simplified approximation of a company participating in the Surprise Game (Ingram *et al*, 2012). The arrows for information flows and decisions are labelled as taking place on the scale of micro time *t* (shorter term) or macro time *T* (longer term).

Putting aside the upper Adaptation segment for the moment, and focusing on Strategy, the word "Rationality" in the K block of Figure 3.2 refers to that chosen one of the Basic 4 rationalities whose decision rule (*f*) is so well tailored to the needs of the current season of risk. In other words, under Rational Adaptation, within the block-diagram scheme of Figure 3.2, just the single Basic 4 decision strategy *f* — with constant time-invariant parameters in its attaching (Group III) model — can occupy the K block at any given point in time (*t*). Accordingly, in any given season, the goal of the feedback control scheme of the Strategy segment is for the season-appropriate decision strategy occupying the K block to facilitate achievement of the desired company cash surplus flows at all times. Such a surplus must be achieved irrespective of the sequences of disturbances $\boldsymbol{d}_1(t)$ emanating from the peril realm of asset behavior in the markets "out there" in the company's "Risk Environment" and impinging upon the assets held by the company, i.e., the S block in Figure 3.2.[23]

Group I: Models of the Risk Environment of the System-Company

Group I models seek to grasp the essence of whatever is determining both the basic nature and detail of the risk environment to which the company is subject. Characterization of the variability in the stream of disturbances originating in the peril realm of the asset market place, and impinging on the insurer's operations as incoming disturbances, the $\boldsymbol{d}_1(t)$ in Figure 3.2, are the essential archetypal subject of Group I models. Pragmatically, the behavior of $\boldsymbol{d}_1(t)$ (and $\boldsymbol{d}_2(t)$ for the Adaptation segment — the behavior of the company's risk environment — may be modeled (for control purposes) as typically a univariate time-series model. In principle, such models could be required for all the variously distinguished disturbance streams, of which two are plotted in Figure 3.2, although for present purposes $\boldsymbol{d}_1(t)$ is the obvious candidate requiring modeling.

The parameters $\boldsymbol{\alpha}(T)$ of a Group I model, presumed equally significantly to vary relatively slowly (with T), may cover not only the coefficients in the univariate time-series representation but also statistics, such as the mean and variance of $\boldsymbol{d}(t)$. Their essential intended purpose is to enable the trajectories over T of their recursively estimated values to track the progression of the seasons of risk, not least as affairs migrate towards and through a qualitative shift in season. Apprehension of the season changing, from Uncertain to whatever, for example, is expressly intended to be detectable through these reconstructed $\boldsymbol{\alpha}(T)$.

Group II: Models of Company-System Behavior

The subject of this second group of models is the dynamic behavior of the S block in the Strategy segment of Figure 3.2. Input-output time-series models of the company's operating behavior (in the S) are presumed.[24] The inputs comprise the incoming disturbances of market volatility $\boldsymbol{d}_1(t)$ and the applied operating decisions of reserving, $\boldsymbol{u}(t)$, which, through the model, evoke outgoing (performance) responses, $\boldsymbol{y}(t)$, such as operating surpluses-losses, asset accumulations, liability accumulations, and so on.

For Group II models the reconstructed trajectories of their $\boldsymbol{\alpha}(T)$ are intended to reveal whether (and how) the structure of the company's operating procedures is changing over time. In effect, they should reveal incipient failure and distortion within the "idealized principles" (i.e., within the idealized *model* thereof) by which the company is dealing with its perceived risk environment through its decisions, i.e., through its risk-coping decision strategy. Ideally, then, one would like to be able to infer something to this effect: that the company's risk-coping strategy and its actual — as opposed to supposed — risk environment do not comport one with the other; that, for example, the Pragmatist with her/his Diversification strategy (one of the f's) no longer comports with the (now erroneously) presumed Uncertain season of risk.

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[23] In contrast to Figure 3.1(b) note how Figure 3.2 has two categories of disturbance streams impinging on the company from its surrounding environment: $\boldsymbol{d}_1(t)$ for the risks associated with the behavior of the asset market; and $\boldsymbol{d}_2(t)$ for the risks associated with the insurance market, notably the performances of other companies. In passing, we may note that to conceive of a companion control theoretic block diagram for the U.S. mutual insurer analyses of the second part of our report (Section 2 above) would entail five such disturbance streams. The three other streams include variations in the regulatory regime, dividend and interest rates, and (as in Figure 3.1) the peril realm giving rise to claims. The block diagram for the U.S. mutual insurer analyses would also oblige us to work with what is called a multivariable controller, i.e., one that has two or more control loops (K blocks) operating in parallel, e.g., one for reserving (as in Figure 3.2), one for premium pricing (Figure 3.1), and a third for company processing-operating decisions, e.g., in respect of decisions about allocating personnel and IT resources. Yang *et al* (2016) provide a good illustration of a multivariable controller, as discussed in more detail in Beck *et al* (2020).

[24] Although much of the work from which the present discussion derives was conducted on the basis of (so-called) state-space, ordinary-differential-equation models, as in Beck (2002).

The focus of our project, however — that very "modeling of the variety in actuarial decision making" — is the subject of scrutiny in the about-to-be-defined Group III models.

Group III: Models of Company Decision-Making Strategy

The K (controller) block in Figure 3.2 is the nub of the matter: the reserving control rule and its decision strategy *f*. It is in these respects we present the novel results and propositions of our project.

In principle, the decision-rule model (of K) may conform to the general rule (of control theory) of being structured as an input-output time-series model. Its inputs are the mismatches between what the company wants, its $\boldsymbol{y}_w(T)$ in Figure 3.2, and what it is actually getting, its $\boldsymbol{y}(t)$, i.e., $\boldsymbol{y}_w(T) - \boldsymbol{y}(t)$. Its outputs are the decisions $\boldsymbol{u}(t)$ deduced from the decision strategy *f* and the input mismatches. Thus, if we label the Pragmatist strategy as f_P, and the Pragmatist strategy has been adopted by the company within its K block because the season of risk is Uncertain, then reserving amounts $\boldsymbol{u}(t)$ are being chosen according to a risk-coping principle of Diversification, i.e., f_P. All should be well, provided the risk season actually is that of Uncertain and remains so. Furthermore, presuming (not unreasonably) that the wants $\boldsymbol{y}_w(T)$ of the Pragmatist are not changing within the span of the current prevailing season of risk (Uncertain), an input-output time-series model of the controller block would be based on the higher-frequency fluctuations in its input $\boldsymbol{y}(t)$ and its output $\boldsymbol{u}(t)$.

But where now does the key instrumental concept of the (slowly) time-varying model parameters $\boldsymbol{\alpha}(T)$ fit into these Group III models? To answer this, we need to reach up to the Adaptation segment of Figure 3.2.

The Adaptor Strategy

In Rational Adaptability (RA) for ERM, something else has to be decided about, and quite *apart* from the decisions being made on a day-to-day basis within the Strategy segment of Figure 3.2. It is, of course, the decision to swap out one version of the autopilot *f* occupying the reserving K block and replace it with another, from time to time, as the seasons of risk to which the company is subject change, over the longer term of macro time *T*. This is supposed to happen according to the essence of the "Rational Adaptability" in the single block of the upper Adaptation segment of Figure 3.2.

Figuratively, and from time to time within macro time *T*, the switch on the output side of the RA block is closed for an instant. The symbolic signal passes to the reserving (K) block in the Strategy segment, and Diversification therein, for instance, is swapped out for Loss Controlling, or Risk Steering, or Risk Trading. Crucially, however, this requires someone in the RA block having somehow apprehended a change of risk season and duly diagnosed the new season of risk (at the earliest possible juncture).

By way of inputs to the RA decision-making process, Figure 3.2 shows that information about asset variability and the states of the market and competitor firms flow in continuously (and conspicuously so) with micro time *t*. What emanates from the RA block, however, is just as conspicuously something that varies with macro time *T*. In fact, to emphasize the distinction, each conceptual signal flow in Figure 3.2 is tagged with either the *t* of fast micro time or the *T* of slow macro time.

We assign the fifth Adaptor strategy as the permanent incumbent of the Rational Adaptability block in Figure 3.2. But when and how might we want to exploit the key concept of time-varying parameters $\boldsymbol{\alpha}(T)$ for a Group III model to account for the behavior of the Adaptor?

3.2.3 SOME PROTOTYPICAL GROUP III MODELS OF AN ADAPTOR STRATEGY

Of these, we envisage three specifically, as follows. Model (1) is supposed conceptually to account for the decision making of the Adaptor rationality taking place in the upper Adaptation segment of Figure 3.2.

Models (2) and (3) are imagined as time-varying *approximations* of the Adaptor's decision strategy taking place in the K block of the lower Strategy segment of Figure 3.2. All three, to reiterate, belong technically to the Group III category of models.

(1) Transition Probability Model

Our first proposition is based on the results of the U.S. mutual insurer analyses of the second part of our project (Section 2 above). Within the block diagram structure of Figure 3.2, therefore, we presume that one of the Basic 4 risk-coping strategies will occupy the K block and remain unchanged until receiving an intervention from the RA block in the Adaptation segment (*via* its switching device). Within that RA block, we conceive of computations taking place along the following narrative lines.

The decision point is marked by t, such that the current-prior strategy, e.g., of Diversification, is that applied from the previous decision point up to time t. The updated-posterior strategy will be that applied to the insurer's operations from t onwards, until the next decision point. It is presumed that the strategy (Diversification) of the Pragmatist has hitherto been applied because, in all probability, the season of risk has hitherto been that of Uncertain (at least in the relatively recent past). Given this, and with prior and posterior now defined, we write of the essence of the Transition Probability model as implementing these calculations:

{Posterior probability of Basic-4 Strategy i (for i =1, 2, 3, 4)}
= ∑(Summation over j, for j = 1, 2, 3, 4) of
[{Prior probability of Basic-4 Strategy j; conditioned upon
current risk Season being that of Rationality j}
multiplied by
{Transition probability i,j of prior Strategy j changing to posterior Strategy i}] (3.1)

To anchor this equation in the frame of the analyses of the U.S. mutual insurer time-series, this last line — the transition probabilities — was the end result of the statistical analyses of Section 2 above, specifically, Tables 2.3 or 2.6. Given the fourfold plurality of the seasons of risk, there are 16 transition probabilities in all.

Subject to diagnosis of the current season of risk — no trivial task whatsoever in the real world (as opposed to in any self-contained foresight simulation) — the above computation can be completed, under the presumption that strategy i strictly accompanies season i. In other words, as decision point t arrives, adherence to the prior Pragmatist strategy of Diversification follows from the determination that the current season of risk is most probably Uncertain. After the above computation, the Adaptor (in the RA block of Figure 3.2) would have access to the four respective posterior probabilities of each of the Basic 4 strategies. If the posterior probability of Diversification is no longer the highest, the Adaptor closes the switch and replaces the Pragmatist occupant of the reserving K block with the alternative rationality corresponding to the strategy with the highest posterior probability. Thereafter, until further notice, that particular Basic 4 rationality will remain in power making the company's decisions according to its distinctive risk-coping strategy.

The 16 transition probabilities become the set of time-varying parameters $\boldsymbol{\alpha}(T)$ at the heart of the model. In the real-time operating world of an actual insurer, with access to data akin to those used in Section 2 above, we conceive of the recursive algorithms cited earlier as supporting, in principle, the Adaptor's capacity to apprehend a qualitative change in the season of risk and to diagnose the category of the new season. We are, of course, not unaware of the profound significance in this of the phrase "in principle". In the foresight-generating mode of the DMA advocated by Clark *et al* (2012), we can imagine that this all-important Group III Transition Probability model, when coupled with its companion Group I and II models, would require the slow temporal variations in $\boldsymbol{\alpha}(T)$ to be generated by some collective of stochastic process models, most obviously those referred to as Generalized Random Walk (GRW) models (along the lines of Young, 1984). Accordingly, given the time-varying transition probabilities, the risk-season transitions and the sequences, the cycles, and the durations of the risk seasons are *not* destined to identically repeat themselves over macro time T and beyond, *ad infinitum* (∞), as it were.

But there is a problem. For can it really be that an Adaptor, looking out on the company's operating environment (in real-time) actually perceives a strict and abrupt *switch* in the season of risk? It is unlikely, on technical grounds, that any reconstructed (real-time) trajectory of an estimated element of the time-varying parameters $\boldsymbol{\alpha}(T)$ of any model would signal an abrupt dislocation in its value between decision points $t-1$ and t, even, one suspects, when Boom turns to Bust.

Our two other types of model serving the Adaptor's (Group III) decision strategy are structures that seek to circumnavigate this problem of abruptness. Both require us to conceive of the approximate surrogate Adaptor rationality occupying (throughout all time) the controller (K) block in the lower Strategy segment of Figure 3.2.

(2) PID Model

The defining acronym of this second model needs to be spelled out. Focusing on the K block of Figure 3.2, the classical design of the archetypal feedback control rule (our decision strategy f) allows for the combination of three types of controller action. Proportional (P) action in control engineering means that the countervailing feedback decision is proportional to the mismatch between what is got and what is wanted at decision point t, i.e., $\boldsymbol{y}_w - \boldsymbol{y}(t)$.[25] Integral (I) action addresses the problem of persistent offset or mismatch, for example, that surpluses are below par quarter after quarter, or whatever. Accordingly, the I action is made proportional to some measure of the integral of the mismatch going back in time, i.e., over $t-1$, $t-2$, $t-3$, and so on. Derivative (D) action has an anticipatory sense about it, in that this constituent of the control action is made proportional to the derivative of the mismatch, i.e., the speed and direction of its change over time. Significantly, if a central difference approximation of the derivative is employed, D action is proportional to the difference between the mismatch at $t-1$ and that forecast in some way for $t+1$. PID control is the composite of all three elements of action.

In the very simplest of forms, with the wants component ($\boldsymbol{y}_w$) of the mismatch deliberately subsumed under parameters $\boldsymbol{\alpha}$, we may write the PID model as

$$\boldsymbol{u}(t) = \alpha_1(T)\boldsymbol{y}(t-1) + \alpha_2(T)\boldsymbol{y}(t) + \alpha_3(T)\hat{\boldsymbol{y}}(t+1) \qquad (3.2a)$$

in which $\hat{\boldsymbol{y}}$ would need to be a forecast — a model-based forecast deriving from an S block Group I ($\boldsymbol{d}$-$\boldsymbol{y}$) model, for example.

Things should work as follows. We have to imagine that this "surrogate Adaptor strategy f" of Equation (3.2a), i.e., the simple linear functional form on the right-hand side of Equation (3.2a), occupies for all time — season in, season out — the K block of the Strategy segment of Figure 3.2. Equation (3.2a) is our first attempt to circumnavigate the significant awkwardness, if not conceptual and practical difficulties, of the abrupt, instantaneous switching function serving the ("true") Adaptor in the RA block of the Adaptation

[25] Argument T has been omitted from the wants, $\boldsymbol{y}_w$. In other words, desires for output company performance across any single season of risk are taken to be unchanging (for the given rationality exercising control).

segment of Figure 3.2. In contrast to all that has gone before — that one after the other of one of the (time-invariant) Basic 4 risk-coping strategies occupies in turn the K block of Figure 3.2 — here now we have a single functional form of a strategy for all time. Crucially, through the device of the $\boldsymbol{\alpha}(T)$, the strategy is enabled to migrate with time among one or the other specific Basic 4 decision strategy (or hybrid combinations thereof). It may figuratively enable the strategy to "touch one or the other base", in whatever sequence matches the sequence of shifts in the seasons of a company's risk environment. But we have yet to demonstrate how this strategy *f* of the surrogate Adaptor embraces distinctive elements of those other strategies of the Basic 4 rationalities. Such a link will follow very shortly.

First, however, as we observed in introducing the PID model of Equation (3.2a), something about it is redolent of a key, but perhaps not obvious, practical assumption in the statistical analysis of Section 2 above. Many of the data streams analyzed therein are, in fact, *differenced* data time-series; and they are so because they were judged to be more indicative of actual styles of insurer decision strategy. While these data are not technically data on the mismatches underlying the derivation of Equation (3.2a), their use emboldens us in conjecturing about how the plural rationalities of the Basic 4 are latent in Equation (3.2a). If nothing more, this instinctive empirical "finding" persuades us likewise to entertain the potential merits of including the $\hat{\boldsymbol{y}}(t+1)$ in Equation (3.2a). Balzer and Benjamin (Balzer, 1982; Benjamin, 1982), for example, found that the D component of their controller's action in fact did not assist in stabilizing the dynamics of claims processing, something that can often be found to be the case in other (engineering) applications.

Grounding the PID Model in Plural Rationality and ERM

Here then is the link between the PID model (Equation 3.2a) and the Plural Rationality and ERM of Appendix A, the Institutional Evolutionary Economics framework of Section 1, and the Rational Adaptability in ERM that shapes the statistical analyses of Section 2. Indeed, this vital link comes with a question: Could there be evidence for guiding interventions by an Adaptor *A*-type in an insurer that may be inferred from the evolving estimates of the model's time-varying parameters $\boldsymbol{\alpha}(T)$? One would not pose this question in respect of using a Group III PID model coupled with companion Group I and II models in an entirely *self-contained* computational foresight-generating exercise. Rather the question is of merit in assessing the potential value of the (real-time) $\boldsymbol{\alpha}(T)$ trajectories as an informative operational decision-*support* device for the Adaptor (as below in Section 3.3.1 of the Adaptor blueprint).

More specifically, the link has much to do with what are referred to as the various social constructions of time of each of the Basic 4 rationalities (Thompson and Rayner, 1998; Douglas *et al*, 2002; Verweij, 2011). To see this, let us rewrite Equation (3.2a) as follows

$$\boldsymbol{u}(t) = \alpha_H(T)\boldsymbol{y}(t-1) + \alpha_M(T)\boldsymbol{y}(t) + \alpha_E(T)\hat{\boldsymbol{y}}(t+1) \tag{3.2b}$$

thereby assigning one parameter each to the Manager (*H*), the Maximizer (*M*), and the Conservator (*E*). The intended social constructions of time are that *H* is "retrospective" in outlook, *M* is "in and of the present (moment)", and the *E* is "anticipatory".

Now reflect on what might be happening with respect to the company's "in principle" decision strategy, i.e., that which ideally "ought to be" in Figure 3.2, as encapsulated in the three-element vector of the parameters $[\alpha_H(T);\alpha_M(T);\alpha_E(T)]$. Suppose it is found — by fitting the model of Equation (3.2b) to the (error-corrupted) time-series streams $\boldsymbol{y}(t)$ and $\boldsymbol{u}(t)$ — to evolve slowly and smoothly through the following sequence of parameter estimates: from [1;0;0]; to [0;1;0]; to [0;0;1]; and to [0;0;0]; and so on. The mix of parameter estimates could be deduced to have passed through the Maximizer strategy, on to the Manager and Conservator strategies, and through to the Pragmatist strategy (the [0;0;0] parameter combination). For this to be so for the Pragmatist, however, we would have to hypothesize that the *P* type runs for cover and battens down the hatches, as it were, at the onset of *its* Uncertain season and thereafter takes her/his hand off the tiller, thereby engaging in a defensive open-loop control strategy. Otherwise, in between the 0/1 entries in the estimated parameter vector, it could be said that various hybrid strategies are being followed by the company (as empirically found in Underwood *et al* (2014), as well as in the foregoing Section 2). And to recall, the mix may vary slowly over the longer-term (T) according to the "weights" of the constituents in the mix, in effect the parameters $\boldsymbol{\alpha}(T)$.

Looked at another way, the vector of smoothly time-varying estimates of the parameters is a means of obviating the abruptness of the Adaptor switch. Which prompts the question of whether, in the real world, there is ever a correspondingly abrupt transition in the season of risk with which the company is having to cope.

(3) Blend (or Hybrid-Mix) Model

With the words "hybrid" and "mix" having just been employed, it is no great stride to arrive at the third of our proposed Group III models for the Adaptor strategy, or more strictly speaking, our second surrogate Adaptor decision function f for permanent occupancy of the K block in the Strategy segment of Figure 3.2.

Four terms (as opposed to three) are to appear in this blend model, however, one each for something of the strategy of each of the Basic 4 rationalities. In addition, the constituent, rationality-specific terms in the model can be made explicit *a priori*, without having to go through something akin to revelation of the social constructions of time *en route* from Equation (3.2a) to (3.2b) above. If anything, the following is more like a smoothly evolving way of fragmenting, breaking down, and blending those archly opposed things that make up the challenge of Decision Making under Contradictory Certainties (DMuCC) for the Institutional Evolutionary Economics of Section 1 above.[26] We propose therefore a style of decision making for the Adaptor A-type as a (simple) function of the constituent candidate decisions of the Basic 4:

$$\boldsymbol{u}_A(t) = \alpha_1(T)\boldsymbol{u}_M(t) + \alpha_2(T)\boldsymbol{u}_E(t) + \alpha_3(T)\boldsymbol{u}_H(t) + \alpha_4(T)\boldsymbol{u}_P(t) \qquad (3.3)$$

Subscripts M, E, H, and P denote the four rationalities as previously, hence their tagged candidate $\boldsymbol{u}$'s. Subscript A, unsurprisingly, signifies the Adaptor rationality.

It is not hard to picture the now four-element estimated parameter vector evolving smoothly but generally slowly among the various 0/1 combinations, and everything in-between. For instance, $[\alpha_1(T);\alpha_2(T);\alpha_3(T);\alpha_4(T)]$ could be estimated to change through the seasons as first [0;0;1;0] (Manager strategy), then [0.5;0;0;0.5] (hybrid Maximizer-Pragmatist), on to [0.33;0;0.33;0.33] (hybrid Maximizer-Manager-Pragmatist), and so on. Section 2 hints at the possibility of such occurrences, as (more substantially) do the earlier results in Underwood *et al* (2014).

(4) Adaptive Control

Needless to say, the possibilities for modeling the Adaptor strategy are several, if not many, not least those associated with the deployment of models in adaptive controllers. Thus, as already observed, when modern control engineering was emerging in the 1960s from classical control engineering, it was becoming possible to embed simple and essentially computationally-concise models within what became known as adaptive controller schemes, themselves in turn embedded aboard the engineering object they were set to control. The guided missile is again the appropriate mental image. One can obtain a sense of the extensive

[26] As opposed to the much more familiar problem of Decision Making under (Risk or) Uncertainty, i.e., the DMuU addressed in Clacher's 2019 IFoA report on "Economic Thought and Actuarial Practice".

scope of what an adaptive controller was supposed to do if we cite one of its alternative names as that of a "self-tuning controller" (Åström and Wittenmark, 1973). The *sine qua non* of success in the performance of the on-board, in-line, digital controller was the capacity of the model always (without fail) to reflect a best current snapshot in real-time *t* of the ever-evolving structure of the missile's behavior (through a Group II model, that is). With recursive parameter estimation and filtering theory co-evolving with such weaponry (see, for example, Jazwinski, 1970; Young, 1984), equally real-time estimates of the ever-changing model parameters $\boldsymbol{\alpha}(T)$ could likewise be generated computationally (precisely because recursive estimation *was* so demonstrably efficient computationally). Thus, originated our device of $\boldsymbol{\alpha}(T)$. It enabled the necessary "best current snapshot".

Indeed, exquisitely careful design judgements would have had to be made to secure this objective — the snapshot — in terms of learning (for adaptation) and unlearning (forgetting the ever-receding past snapshots). Learning and unlearning have their counterparts among the styles of the Basic 4 rationalities, not least in what we can perceive now of the benefits of *deliberately* forgetting, in order to arrive at the Rumsfeldian "unknown knowns" (things now unknown that were once known), which are associated with the Pragmatist rationality (and explicitly so in the IFoA's study of model risk; Aggarwal *et al*, 2016; see also Beck *et al*, 2020).[27] Moreover, it is possible to draw a parallel between the assigned and distinctive strategy of the Adaptor — to deliver the ever-best snapshot — with the risk-coping styles of prominent members of the hermit-proximate Sherpa, notably mountaineer Ang Phu (Thompson, 1982).

Technically, of course, it is the control engineering device of the time-varying parameters — the $\boldsymbol{\alpha}(T)$ at the very heart of our way of modeling variability in actuarial decision making — that enables our shaping herein (and subsequently deploying) the essential strategy of the Adaptor rationality. This brings us to the second tranche of novel results in this third section of our project.

3.3 BLUEPRINT FOR THE ADAPTOR STRATEGY

The Adaptor, the fifth of the plural rationalities, should necessarily stand apart and be distinct from the other Basic 4 rationalities, of Maximizer, Manager, Conservator, and Pragmatist. In principle it should occupy exclusively the single block in the Adaptation segment of Figure 3.2 (which is based on the Surprise Game), whereas the other four are all occupants for some season of risk of the controller K block of the Strategy segment. In the foregoing, however, and as a simple first step, we have approximated (and modeled) a surrogate of the "genuine" Adaptor strategy in the PID and Blend models: as a smoothly time-varying permanent incumbent of the K block of the Strategy segment. The essential and defining "otherness" of the Adaptor, in all its respects, is an entirely untapped conceptual resource for reasoning about ways to improve the risk-coping endeavors of insurers. Like the preceding modeling propositions, however, any proper development of the blueprint for the Adaptor (other than the beginning now to follow) is a matter for investigation well beyond the scope of the current project.

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[27] Having cited Rumsfeld, it is timely to note this. Modeling the variety of actuarial decision making is not just a matter of variability as a function of *time*, as treated herein. It is also a function of *certainty-uncertainty* and of the *social-power dynamics* among those groups of employees influencing an insurer's decision making. In research prior to the writing of this report, both were investigated extensively, in particular the former. In effect, the Basic 4 rationalities cover four stances on certainty-uncertainty, i.e., four significantly different classes of Decision Making under Uncertainty (DMuU) — roughly, according to the four pairwise combinations of "knowns" and "unknowns". None of this preparatory work is reported upon herein. Variability as a function of social-power dynamics, however, will be touched upon later.

3.3.1 OPERATIONAL DIAGNOSIS OF SURPRISE AND RATIONAL ADAPTATION

The surprise typology of Rational Adaptation (RA), so central to our earlier work on PR in ERM (*InsuranceERM*, 2009-13), is given as Table 0.1 in the Introduction of this project report. It requires the capacity, somewhere within the insurance company, to apprehend that the season of risk in its operating environment has changed; that technically there has been a qualitative shift in the nature of the variations in the incoming disturbances $\boldsymbol{d}(t)$ of Figure 3.2. RA then requires exercise of the capacity of the company to diagnose to which specifically of the four seasons of risk (Boom, Moderate, Bust, Uncertain) things have shifted.

But Why Not Charge the Basic 4 With the Task of Diagnosing "Surprise"?
The answer to this question comes down to the data and, crucially, to who chooses which components of them to heed and which to ignore.

At any decision point, therefore, let us suppose $\boldsymbol{d}$ and $\boldsymbol{y}$ are the "true" values of data on respectively the company's risk environment and operational performance, i.e., on the inputs and outputs of the "Assets" (S) block in Figure 3.2. In practice, these $\boldsymbol{d}$ and $\boldsymbol{y}$ are not observed. Only their counterpart error-corrupted values, $\boldsymbol{d}'$ and $\boldsymbol{y}'$, say, are available for understanding the world and acting in it. There is noise in the observed data of the evidence base for actuarial decision making. The truth is seen through the frosted glass of the prime (′) notation.

Cultural theory, our theory of plural rationality, acknowledges the fact that with any world view comes a mindset that takes heed of some things and ignores others. In effect, for each of the Basic 4 rationalities the world is being seen through a second layer of almost willful distortion and obfuscation, as $\boldsymbol{d}''$ and $\boldsymbol{y}''$ we may write, using the double prime (″) notation. Evidence, as we well know, may be selected to confirm one's world view. We may write that the world is observed by the Maximizers as $[\boldsymbol{d}'_M ;\boldsymbol{y}'_M]$, by Managers as $[\boldsymbol{d}'_H ;\boldsymbol{y}'_H]$, by Conservators as $[\boldsymbol{d}'_E ;\boldsymbol{y}'_E]$, and by Pragmatists as $[\boldsymbol{d}'_P ;\boldsymbol{y}'_P]$. Here, the subscript is being used to signal the rationality-specific "biasing" of the heed taken (or not) of the constituents of the error-corrupted observations $[\boldsymbol{d}';\boldsymbol{y}']$. Less cumbersome is to write of the observed (O) world being simply O_M, O_H, O_E, and O_P for the four rationalities respectively (at any decision point t in time).

The truth is one thing, $[\boldsymbol{d};\boldsymbol{y}]$. What can be empirically observed of it in the real world is yet another, $[\boldsymbol{d}';\boldsymbol{y}']$. What is heeded of the empirically observed is yet another, or rather, is yet four others, O_M, O_H, O_E, and O_P. We have four plural "takes" or "spins" on the state of the world, upon which to base the making of actuarial decisions using the respective decision-making rules of the Basic 4 rationalities. In which case, let us consider what might happen when the season of risk changes, from Moderate, to Uncertain, to Bust, to Boom or whatever. Absent the Adaptor from the original exposition of RA, we submit now that the operative decision strategy f_i will *not* change. The presently "successful" Basic 4 rationality will *not* be surprised into changing its ways or yielding its grip on the decisions being enacted. It will not apprehend the failure of its ways; it will insist on spinning its O_i so as to convince itself the evidence base is demonstrating continuing success.

It is for this reason we charge the Adaptor rationality with the tasks of RA.

The Focal Role of the Time-varying Model Parameters
Our intention is that models may be deployed to support the Adaptor in discharging this responsibility of diagnosis within the scheme of RA. The word "support" is important, because our concern now is to envisage models as being run "off-line" in support of the making of the current decision. The models are now not supposed to be encoded in the computer as a "self-contained" simulation of the entire affairs of the company, including its strategies of decision making, for the current and all future simulated decision periods. The model here is not simulating the making of the future decisions. More specifically, it is our

contention that the device of time-varying model parameters **α**(T) enables and enhances discharge of this task of operational diagnosis.

Unsurprisingly, we posit that the kernel of such diagnoses — of whether the season of risk has changed and, if so, to what? — lies in the device of the **α**(T) in any of these model structures. Which device permits the possible revelation (under uncertainty) — through the recursively reconstructed estimates of the relatively slow temporal patterns in the **α**(T) — of significant and diagnosable information about qualitative structural change in the system and its risk environment.

For the servicing of this purpose there is much precedent (as in Beck, 1979, 1983, 1987, 2002), including a recent treatment of the same in respect of actuarial model support for RA in ERM (Beck *et al*, 2020). This precedent originated in the notion of testing the structure of a model of a system's behavior to the point of failure and destruction. What was sought in this, however, was *not* the revelation that the model *as a whole* was failing or plain wrong. It was rather exposure of the fact that one or more of its *constituent* parts (its constituent hypotheses) was failing, together possibly with how it was failing (in what way, if not why). For present purposes, such failure is presumed here to occur because of some change in the structure of the real system's behavior over time, which does not comport with the "null hypothesis" that the model in all its parts, in respect of all of its parameter values **α**, is correct and *invariant* with time.

Suffice it to say merely this, therefore, on this potentially voluminous subject. If the estimates of the **α**(T) are invariant with time in any model structure, the presumption of the model being correct is not significantly denied. Otherwise, something not ascribable to pure chance in the data streams — the $\boldsymbol{d}(t)$, the $\boldsymbol{y}(t)$, *and* the sequence of decisions $\boldsymbol{u}(t)$ — does not comport with some feature in these data.

All Three Groups of Models May Serve the Purpose

A Group I model of the variations in $\boldsymbol{d}(t)$ is an obvious choice for serving this purpose of diagnosing a changed season of risk. In principle, in the case of Figure 3.2, one model for each of the two risk streams ($\boldsymbol{d}_1(t)$ and $\boldsymbol{d}_2(t)$) would be needed. We may also argue, however, that the Group II models and the Group III models have a role to play, *except* for the transition-probability model of Equation (3.1). It is hard to conceive (as yet) how such a model would work for the purposes of (real-time) operational diagnosis of any shift in the season of risk.

To summarize the particulars, in deploying a Group I model the hope is of diagnoses along these lines: that irrespective of company behavior, the external season of risk may be concluded to be this, that, or the other.

With a Group II model (for Assets behavior in Figure 3.2) one might hope to elicit the conclusion that the reserving actions $\boldsymbol{u}$ being taken to counter the (generally) deleterious consequences of the incoming disturbances $\boldsymbol{d}$ for company performance, surplus $\boldsymbol{y}$, are not succeeding, i.e., that (the presumed known) decision strategy does not appear to be addressing the issues of the current season of risk. For instance, the parametric variations might signal that, while the current season of risk (from the Group I model and its respective **α**(T)) is Uncertain, the pattern of the $\boldsymbol{y}$, when reconciled (*via* the Group II model) with the patterns of the $\boldsymbol{d}$ and $\boldsymbol{u}$ appears to be more the consequence of the Manager's strategy of Risk Steering than of the (presently season-correct) Pragmatist's Diversification.[28]

[28] Technically, the models are of course not reconciled against the hypothetically observed "true behavior", but the error-corrupted observations thereof, i.e., the [$\boldsymbol{d}'$,$\boldsymbol{y}'$], if not error-corrupted records of past decisions $\boldsymbol{u}$ as well. In contrast, if the logic of Cultural Theory holds, any one of the Basic 4 rationalities would seek to reconcile *its* models with *its* respective take on the data, namely the [$\boldsymbol{d}''$,$\boldsymbol{y}''$], which, one

For a Group III model, of the K decision block in Figure 3.2, the hope would be this: that its outgoing (feedback) actions ***u*** are inconsistent with this K block's input company performance data ***y***, *but* with an attaching hint of what evolving blends of strategy (or hybrid decision strategy) might actually succeed.

All the foregoing are conjectures, however; and conjectures moreover, in the very (very) early days of reasoning through the blueprint of the Adaptor. Nevertheless, for the purpose of diagnosing a qualitative shift in the company's risk environment, there does appear to be a reasonable *prima facie* case for asserting that some trace of seasonal change should be evident in the estimated variations of the $\boldsymbol{\alpha}(T)$ populating the univariate time-series (Group I) model of the company's $\boldsymbol{d}(t)$.

Taking stock of this charge (of diagnosing surprise under the rubric of Rational Adaptation), *all* of the evidence — the error-corrupted data streams $[\boldsymbol{d}',\boldsymbol{y}']$, the time-varying estimates of the various $\boldsymbol{\alpha}(T)$ in the three Groups of models, and the kind of evidence implied in the surprise typology of Table 0.1 (Introduction) — passes into the purview of the Adaptor. Indeed, as if to gild the lily, there are yet other ways of generating diagnostic evidence for guiding and supporting decision making under the Adaptor strategy (Beck *et al*, 2020).

In the context of future possible actuarial practice, the following nevertheless is salient. What is to be put to work in developing the blueprint of the Adaptor are the conceptual principles of problem-solving according to control engineering, *not* (necessarily) the undergirding mathematical fineries typically associated with control theory.

But there is a potentially disruptive undercurrent circulating beneath these principles of diagnosing a qualitative shift in a company's season of risk.

A Confounding Factor: Social-power Dynamics Among the Basic 4 Solidarities of Company Decision Influencers

The primary determination of RA must be this: Are the current season of risk and the currently applied risk-coping strategy logically consistent with one another according to the theory of plural rationality? The consequent determination is whether the season is correctly identified, but that the current decision strategy is not logically consistent with it.

Something not so far discussed, hence completely absent from any models and, indeed, from the scheme of RA, is this. Consider each of the Basic 4 rationalities. Each, in principle, wants to have things its way; each wants to have control of the mechanics of decision making in the company; to be the autopilot in the company driving seat. According to Cultural Theory, in particular, in the last chapter of *Organising & Disorganising* (Thompson, 2008), a three-dimensional visualization is given of how a theory of the dynamics of power and control over social affairs, including the making of decisions, might be played out among the plural rationalities in any organization or institution. The visualization appears on page 144 of the book.

Significantly, for the metaphor that follows shortly, the word "grip" is used as a measure of the power and influence (persuasive or coercive) any one rationality may exercise over any other rationality. Grip is gauged up a vertical axis in the 3-D visualization. An illustrative curved topographical surface mapping the contours of power stands above the 2-D "control space" formed by the two original axes of Cultural Theory for plotting an agent's social context, i.e., grid and group. Five points of stability are plotted in five

suspects, would minimize that rationality's chances of ever apprehending that something is wrong or has changed. In this, we find another reason to charge the Adaptor with the task of operational diagnosis of surprise within the scheme of RA.

respective domains of stability on the 2-D plane (one for each rationality), together with the trajectories homing in on each stability point. These trajectories trace how the grid-group status of an individual agent should evolve — in respect of being signed up to membership of any one of the solidarities of PR — from wherever they might find themselves on the grip (power) surface above.[29]

Keeping the idea of grip in mind — as in the exercise of power and influence (or the lack thereof) among the plural groupings of employees in an insurer — picture now this metaphor. It is from the Introduction to the second (2017) edition of the 1979 book *Rubbish Theory: The Creation and Destruction of Value* (Thompson, 2017; pp 4-7). The 1979 theory of value is being recast within the subsequent 1990 theory of plural rationality, i.e., *Cultural Theory* (Thompson *et al*, 1990). A system's diagram, one essentially similar to the block diagrams of control engineering (such as Figures 3.1 and 3.2), charts the possible (and not possible) flows of objects or goods among the value categories of "transient", "durable", and "rubbish". The categories are the blocks (cisterns in the book); the flows of goods are the arrows between any pair of blocks. Taps associated with the flows (arrows) are imagined, as the means to control the magnitude of a flow. The taps would be referred to as the actuators in control engineering, i.e., those things that actually apply the deduced control actions to the system. They give effect to the decisions emanating from a conceptual controller block. Each rationality is imagined as placing its hands on the tap, four pairs of hands, that is, for the Basic 4 rationalities. That pair of hands (rationality) with the greatest, most influential grip on the tap has its way. One rationality, the one *currently* in power, determines and gives effect to the current risk-coping strategy of the insurer, in the K block of Figure 3.2.

The trouble for Rational Adaptability, and for all the preceding propositions for the Adaptor's task of operational diagnosis of the season of risk, is the potentially disruptive nature of the unfolding social-power dynamics. In particular, the members of one rationality may — over time, perhaps slowly (as over macro time *T*), perhaps more rapidly, over micro time *t* — "predate" the members of another rationality, or coerce, or try to persuade them to shift their allegiance: from a competing rationality to theirs; hence to buy into a different risk-coping strategy. The narrative of the Insurance Cycle provided by Underwood and Ingram (2013) is replete with the empirical experience of just such.

The potential difficulty for RA, is that a change of grip over the company's risk-coping decision strategy, from one of the Basic 4 to another, may occur in the complete absence of any accompanying change of risk season. In which case, the season of risk and the company's risk-coping strategy would not be logically consistent with one another, according to the theory of plural rationality. Perhaps the Adaptor, standing determinedly quite apart from the social-power dynamics of the Basic 4 and equally hermit-like utterly disengaged from them, could detect something of this nature, even in the (possibly enduring) absence of any model of them.

[29] Some clarification of phrasing and terminology will be helpful at this juncture. "Grip" is not only tantamount to "power" but also, in our everyday language, to "control". However, in a discussion where control theory and control engineering provide the intellectual spine, care in the use of words (in certain places) is important. Thus, first, this notion of grip is due to a Canadian engineer, Nils Lind, perhaps even a control engineer. Yet merely through its appeal to alliteration, of grip, grid, and group, one can appreciate why grip is being employed in the present setting of Cultural Theory. But then there is the phrase "control space", as used (in *Organising & Disorganising*) for the two dimensions of grid and group in the 3-D visualization. For what this 2-D plane represents, a control engineer would refer to the details of plural stability domains (or basins of attraction) plotted on it as technically the "phase plane" portrait of stability in the (unforced) transient dynamic behavior of a system. In slightly more readily understandable words (from control and systems theory), the 2-D plot has two system "state" (output) variables for its axes, such that the trajectories in the plot signal the pair of two state-output values at any point in time through which the entity (an agent in this instance) passes as it returns to stability from its initial state of displacement out of stasis or equilibrium. In the case of an insurance company two of its states-outputs could be the company's accumulations of assets and liabilities. The phase plane portrait will become important (shortly) in Section 3.3.2, in respect of grasping an important distinction between the notions of stability and resilience.

3.3.2 MYTHS OF NATURE, RESILIENCE AND SCALES OF TIME

It is possible the reader could be wondering why the distinction has been drawn (so strongly) between change in the shorter term, i.e., change in micro time *t*, and change over the longer term, over macro time *T*. We surely trust this is not the case, but if it is, here is yet a further reason why this distinction is so very important in so many ways, including in respect of PR for ERM. It resides in the perhaps often neglected but profoundly important distinction between stability and resilience. In fact, we must go further now, to define and label formally a third overlapping scale of time: the "quasi-evolutionary" denoted by the symbol ∞ already introduced for the very long term. Which very long term here will be on the scale of economic cycles, Kondratieff waves of innovation (Section 1 above and Appendix B), and the dynamics of climate change. In short, the trio of *t*, *T*, and ∞, will serve as our scales of time.

Each of the five rationalities of Cultural Theory has an attaching Myth of Nature, a social construction of nature, of the way the world is. They are touched upon in Section 1. These Myths are originally due to ecologist C .S. Holling (1977). Their expression followed shortly after his seminal paper on "Resilience and Stability of Ecological Systems" (Holling, 1973). In spite of this distinction's presence in the paper's title, it has subsequently been all too easy to lose sight of the roots of the distinction between these two systemic properties (of stability and resilience).[30] Yet more of the "Adaptor exceptionalism" accumulating in this blueprint will now become apparent. The Adaptor's Myth of Nature is that of Nature *Resilient*; all of the other Basic 4 Myths have to do with variations on the theme of *stability*. Indeed, since resilience is associated with the behavior of any system over the *longer* term (of the *T* and∞ time scales) — and since insurers with products in the domain of pension funds ought to be greatly concerned about asset and investment behavior in the long term — resilient company performance (as opposed to short-term stability) ought to be a prominent consideration in everyday decision making. To put it bluntly and technically, actuaries (above all others) must contemplate the ∞ and then wind the implications therefrom back through *T* to decision making in the here and now of *t*. Holling's seminal work, we judge, is more informative on the matter of resilience, with its horizons spanning the ∞ and the *T*, than many others of the many attempts to get to its very essence.[31]

Quick Time, Stability, and the Myths of the Basic 4 Rationalities

A phase-plane portrait of a system's stability, or more commonly a topographical ball-surface icon (see, for example, Thompson *et al*, 1990; Thompson, 2008), can be drawn for each of our Basic 4 rationalities of ERM, Maximizer, Manager, Conservator, and Pragmatist. For the iconography imagine a ball on a surface. The joint narrative of the portrait and icon is as now follows.

To begin with, the ball may be in stasis, with its position on the surface invariant with time, at the point of equilibrium-stability. Much more likely, however, is that the ball will be in motion upon and about the surface. Its movement, its changing position with time, is the metaphor for the transient behavior of the state of the insurer (effectively output ***y*** here), for instance, the changing value of its accumulation of assets (as the single state variable for the ball-surface icon) or the varying combination of asset and liability

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[30] The word "systemic" here is being used specifically and precisely to signal properties *inherent* to the dynamic behavior of a disturbed *system* whose state has been pushed out of stasis.

[31] Deciding today how to invest for the long term (decades hence) can be said to be the driving motivation for the recently launched (2020) Financial Systems Thinking Innovation Centre (FinSTIC) of the U.K. IFoA (see finstic.org,uk). Silver's 2017 book *Finance, Society and Sustainability* is a damning indictment of the finance industry for its short-termism (Silver, 2017). The same is prominent in the 2019 Clacher Report commissioned by the IFoA on *Economic Thought and Actuarial Practice* (Clacher, 2019). We shall have more to say on this shortly (https://www.actuaries.org.uk/system/files/field/document/Economic_Thought_and_Actuarial_Practice_0.pdf).

accumulations for the location of the insurer's performance in the two-state, 2-D, phase-plane portrait of stability. The movement of the ball is supposed to be the consequence of its being struck in some way by an imagined "off-stage" and equally iconic billiard cue, as metaphor for the disturbance ***d*** emanating from the company's external risk environment. Finally — and this, we might say, is the bottom line here — if we are going to reference change (movement) to slow time *T* for the affairs of the Adaptor, as we are below, then *relative* to *T*, all of the movement of the ball over the stability surface or the movement of the state of the system about the portrait will be measured as occurring in *comparatively* quick time *t*.

Given the ball-surface iconography and the phase-plane portrait, each of the Basic 4 rationality's Myth of Nature and its accompanying social construction of stability (not resilience) can be expressed as follows:

> The *Maximizer* holds that Nature is Benign. No matter how much and how hard the system is struck by disturbance, things will return to the equilibrium point Maximizers have come to know and love. The system's behavior is mean-reverting. The ball-surface icon is bowl-shaped (U). If struck by the billiard cue and displaced from stasis at the bottom of the bowl, the ball always will eventually return to that stasis (to that equilibrium point) at the bottom of the bowl. In the phase-plane portrait, the surface contours of the bowl shape are plotted as concentric circles; the state of the system, when disturbed away from the center-most stability point, traces out a trajectory crossing the circles and returning back to this point of stasis. The dynamic behavior of the system, all in quick, micro time *t*, is said to be unconditionally stable.
>
> The *Conservator*, in complete contrast to Maximizers, cleaves to the Myth of Nature Ephemeral. The iconic bowl-shaped surface is upturned; it is ∩-shaped. Only an utterly precarious stability obtains at the peak of the upturned bowl. Any perturbation of the ball, no matter how minuscule, will cause it to crash off and into some abyss (of disaster) somewhere. The state of the system, once perturbed away from the precarious stasis, will pursue a trajectory, perhaps with an ever-increasing speed of change, that sooner or later will seek to break out of the frame of the phase-plane portrait. We have an intuitive sense of all this in the risk season of Bust. The system is said to be unconditionally unstable.
>
> The *Manager* claims her/his Myth as that of Nature Tolerant but Perverse. Significantly, this is the only Myth requiring two adjectives. Its accompanying surface is that of a bowl with its rim turned downwards. The behavior of the system is conditionally stable. Up to a point, company affairs will mimic the dynamics of the ball remaining within the bowl: stability. If struck too hard, however, the ball may be metaphorically propelled all the way up to the rim of the bowl, over, and out: instability. Conventional ERM works, we might say, provided the company does not experience any unacceptably large, risky, event. In the phase-plane portrait, one of the outer concentric rings will equate to the rim of the bowl. Realization of the high-amplitude risky event causes the state of the insurer to follow a trajectory (through quick time *t*) that crosses this outer circular (rim) boundary, never to turn back towards the center.
>
> The *Pragmatist* has assigned to it the Myth of Nature Capricious: no bowl, merely a flat-land; no contours in the phase-plane portrait, nor any point of equilibrium. The ball, struck any and every which way by the billiard cue, traces out a trajectory in *t* zig-zagging about the phase-plane portrait (as the ball is struck again and again by the stream of ***d*** striking the company), perhaps remaining within the frame, perhaps not. The ball has no point of stasis at which to come to rest. The dynamic behavior of the system is technically

> neither stable nor unstable. And yet, for all this seeming negativity about the Pragmatist's Myth, there can be several positive elements within it in respect of a risk-coping strategy. We mention but one, because it presages the imminent exceptionalism of the Adaptor in respect of our appreciation of resilience. Thus, in the practice of an insurer, the Pragmatist may recognize — or pursuit of a (reactive) strategy of Diversification may signal — that the old order or structure of the world in which the company is operating has disintegrated, yet the nature of any new order to come is not discerned (or even not discernible for the time being, in this Uncertain season of risk).

It is time to shift our attention from the local property of stability in quick time t to the global property of resilience in slow time T.

Slow Time, Resilience, and the Myth of the Adaptor Rationality

Since our Adaptor is being assigned Holling's fifth Myth of Nature Resilient, in which the property of resilience is said to be global, this Myth may rightly be supposed to subsume in some way — indeed, in some way still being elaborated (and possibly destined ever to be so!) — all of the locally circumscribed behaviors of the other four Myths. But we shall be brief.

Each of the four ball-surface icons and phase-plane stability portraits for each of the Basic 4 rationalities encapsulate the short-term transient behavior in the state of the company's output performance $\boldsymbol{y}(t)$ in response to perturbation and disturbance. We may refer to these as *local* properties of the system's behavior in time, specifically within the short scale of time indicated by micro time t.

Each iconic form may be thought of as a snapshot, a still photograph, or a single frame in a film: of how short-term transient behavior $\boldsymbol{y}(t)$ varies in a particular manner — according to the given Basic 4 rationality and its attaching Myth of Nature — for the duration of each season of risk over the scale of macro time T. In particular, this being so, the Myth of Nature Resilient of the Adaptor can be drawn as that which encompasses the gradual morphological (structural) transformation of the (stability) surface from one season of risk to the next, over the longer-term of multiple seasons within broadly still the temporal scale of T. The transformation is as that of an animated cartoon film in macro-time T. It is as that introduced above for the slowly but inexorably changing structure of the aircraft's dynamics as it expends fuel.

Each of the four phase-plane portraits, while likewise capable of sustaining quite the same animation over the dimension of time, can also be supposed to be but a single (locally defined) tile in the full global mosaic of the stability properties of the company's dynamic behavior $\boldsymbol{y}(t)$ over its global range of conceivable values for, say, the asset and liability accumulations comprising the $\boldsymbol{y}$. That mosaic — the complete composition of the host of tiles of constituent local stability maps — may be regarded as, in fact, a portrayal of the global systemic property of resilience, subsuming, as it does, all the (in fact) many tiles of local systemic stability. And that is how the distinction between resilience and stability was originally conceived of in Holling (1973).

Time, however, remains our focus, as does our control theoretic device of time-varying parameters $\boldsymbol{\alpha}(T)$. Together, they yield this fundamental distinction between the rationalities of the Basic 4 and the Adaptor rationality, between respectively stability and resilience:

> The engine of the animation connecting the stills into the film for the never-ending qualitative (structural) shifts in the short-term transient behavior $\boldsymbol{y}(t)$ of the company, as it experiences and undergoes the companion shifts in the seasons of its risk environment, is the relatively slow changing of the $\boldsymbol{\alpha}(T)$.

What is more, technically, the high-frequency buzz and flutter in the movement of the ball (the $\boldsymbol{y}(t)$) may influence the low-frequency rumbling and shifting of the $\boldsymbol{\alpha}(T)$, and every bit as much *vice versa*. Tentatively, we draw also this further distinction. The reconstructed variations in $\boldsymbol{\alpha}(T)$ are to the Adaptor what the observed (or spun) variations in the evidence base of the $\boldsymbol{y}(t)$ are to each of the Basic 4 rationalities in respect of decision making, i.e., in respect of Rational Adaptability in ERM. The global $\boldsymbol{\alpha}(T)$ are indicative of the notion of longer-term resilience in the way that the local $\boldsymbol{y}(t)$ are indicative of stability in the short term.

To put palpable actuarial flesh on this abstract, control-theoretic skeleton of a principle, we offer these two images. First, in the animated film of the Myth of Nature Resilient as visualized in Thompson (2008), the economic-business cycle from Boom to Bust would begin with the rim of the U-shaped surface of Boom turning down into the season of Moderate and, with the ever progressive turning down and flattening out, into the flatland still of Uncertain, and eventually, as a bump manifests itself and rises up in the flatland, the Bust of the upturned ∩-shaped bowl. Second, Diks *et al* (2015) and Rye and Jackson (2016) have sought to identify the progressive weakening over time (T) in the restorative forces of a national economy subjected to the occasional disturbance of bust and collapse (as manifest in long GDP time-series, over a time-scale edging towards that of ∞ for economics). To buttress their analysis, they liken the behavior of a national economy to that of a disturbed mechanical spring-mass-damper system and invoke the theory of catastrophe. The surface of the ball-surface iconography is supposed to be undergoing structural (morphological) change as a function of what catastrophe theory refers to as a “control parameter”, i.e., an $\boldsymbol{\alpha}(T)$, such that as the value of this parameter passes a critical (cusp) point, the pattern of high-frequency fluctuations in national GDP, the $\boldsymbol{y}(t)$, undergoes a significant, qualitative change (technically, more oscillatory in form as a function of the weakened restorative forces in the economy). The original U in the surface of the ball-surface iconography for the national economy slowly shallows and flattens, eventually tipping the ball of GDP performance over and out in a newly forming U in another zone of the phase-plane portrait. Over the span of the long term (T and ∞), the relatively short-term (t) recovery of the GDP of an economy subject to a Bust in, say, 2008, will be qualitatively different (notably more oscillatory and “bouncy”) than was the recovery when that same economy was subject to the (hypothetically) identical Bust disturbance in 1978, say.

How exactly the Adaptor might act so as to preserve or enhance resilience in the insurer’s behavior over the long term is something to be addressed below (in Section 3.3.4). More immediately, the Adaptor’s social construction of time must be touched upon, as follows.

Although the fourth of the Group III models in Section 3.2.3 (for models as they might be found in adaptive, self-tuning controllers) has yet to find a more formal place in our diagnosis of surprise, hence support the implementation of RA (in Section 3.3.1), its essence nonetheless gives us a rough working conjecture for the Adaptor’s social construction of time. Oddly, the metaphor of a guided missile once again serves our purpose. We shall also need to avail ourselves of the three scales of time over which variation and change may occur: the short term t, the long term T, and the quasi-evolutionary, ∞. In respect of this last we have in mind specifically the timescale referencing the evolutionary economic behavior set out in Arthur’s (2009) book *The Nature of Technology. What It Is and How It Evolves*. It would be the same temporal scale as that covering the cycles and Kondratieff waves addressed in the Institutional Evolutionary Economics (IEE) of the first part of our project (Section 1 and Appendix B). We have thus this social construction of time for the Adaptor:

> The evidence of the way the world is, upon which the Adaptor should seek to base an intervention in company affairs, is the “best current snapshot”, *not* of the current company performance in and of the moment, i.e., $\boldsymbol{y}(t)$, but of the current, momentarily arrested, ever-evolving structure, $\boldsymbol{\alpha}(T;\infty)$, of how the company is currently functioning,

> subject to a most judicious balance between learning about future such structural essences and forgetting about those past.

To make an "intervention" in the terms of control engineering, however, requires a knowledge of the Adaptor's "wants", which obliges us, unfortunately, to grapple with the conceptually elusive systemic property of resilience in more specific, technical terms — to culminate thus in Section 3.3.4, after what comes next.

3.3.3 PLURAL WAYS OF ECONOMIZING—WHAT THE ADAPTOR BRINGS TO INSTITUTIONAL EVOLUTIONARY ECONOMICS (IEE)

Fifty percent of what could be involved in strategies of actuarial decision making is missing from the block diagrams of Figures 3.1 and 3.2. To appreciate this rather shocking acknowledgement, bear down on the comparator junction in either figure. It is the circle containing the summation symbol Σ, into which flows the signal on company performance ($\boldsymbol{y}$) and the signal specifying the company's "wants" for that performance, i.e., $\boldsymbol{y_w}$. Now reflect on how this latter (generally taken for granted by the control engineering draftsperson, as specified by someone else!) seems to be parachuted into the affairs of the company from somewhere off-stage, off-diagram. This, of course, is *not* the case. For it is entirely feasible, in principle, that those decision-influencers conceptually lodged inside the reserving control (K) block of Figure 3.2, or inside the premium-setting control (K) block of Figure 3.1, could decide about not only what should be done to change the $\boldsymbol{y}$ — the fifty percent we have supposed they do indeed do — but also what should be done to change the other half, the company's wants $\boldsymbol{y_w}$. What may emanate from these K blocks in one direction, back into the company's operating mechanisms (the S block), may be accompanied, in principle, by an arrow feeding back to the something "off-stage", which something may change the $\boldsymbol{y_w}$ desires of the company.

The foregoing can be drawn in the setting of Figure 3.1 for each of the Basic 4 decision strategies. But again, consideration of what is to be done in respect of the Adaptor must be reasoned about in the more complex frame of Figure 3.2. All five rationalities taken together, nevertheless, allow us to reason first about the similarities and differences among the five plurally rational ways of economizing expressed in Thompson (2010). "We Are Plurally Rational and Inherently Relational", as Section 1 proclaims. And this gives us the Institutional parent of IEE, to which we shall return (very shortly). But it is the dimension of *time* and Evolutionary Economics, especially as expressed in Arthur (2009), that gives us the more complete form and scope of IEE.

The "Evolutionary" About It All

To begin to appreciate this, we must conceive of four co-evolving systems, written in parentheses {·} as {"Mobilizable" Resources}, {Technology}, {Economy}, and {Human Needs-Wants}. The {"Mobilizable" Resources} in conjunction with the {Technology} constitute jointly our common-language "means"; whereas the {Human Needs-Wants} constitute our everyday "ends". Thus, the {Economy} can be taken to be, in essence, about the challenge of reconciling "ends" with "means", hence the plural ways of economizing.

Each system merits a minimum of further qualification:

> {"Mobilizable" Resources} amount to natural capital, social capital, intellectual capital, financial capital, and so on.
>
> {Technology} includes "all the myriad devices and methods and all the purposed systems we call technologies" (Arthur, 2009; pp 192-3). It entails much more than widgets, machines, mills, locomotives, and the like (again in Arthur's words): "markets and pricing

systems"; "trading arrangements, distribution systems, organizations, and businesses"; and "financial systems, banks, regulatory systems, and legal systems ... the New York Stock Exchange". Significantly, for our purposes here, we may treat company decision strategy as an element of the ever-evolving {Technology}. "All these", Arthur continues, "are arrangements by which we fulfill our needs, all are means to fulfill human purposes" — all are "*purposed* systems" (emphasis added).

{Economy}, or the ways of economizing, is the focus around which, as we say, means and ends are reconciled.

{Human Needs-Wants} are those abstract notational wants $\boldsymbol{y_w}$ parachuted into our block diagrams of Figures 3.1 and 3.2. According to Thompson (2010), they derive from the utopia to which we hold fast, on the never-ending journey to what should be the eventual condition of the world. Crudely and instrumentally put, currently prevailing wants — as in the subscript lower-case "w" of the $\boldsymbol{y_w}(T)$ for company performance in Figures 3.1 and 3.2 — are derived from the upper-case subscript "W" of the $\boldsymbol{y_W}(\infty)$ of the utopian vision.

The very long, quasi-evolutionary, time-scale of ∞, having to do with our utopia, which *do* influence what we want in the prevailing season of risk (T), come down to influence the actuarial decision making of the here and now in immediate present of time-scale t.

We must also tag each system, therefore, with a characteristic time-scale (or two, or three) over which significant change may take place:

{"Mobilizable" Resources} vary typically over the short (t) and long (T) terms as the resources at our disposal are being mobilized in the day-to-day production of goods and services.

{Technology} varies according to t, as in the everyday, operational decision making of the Basic 4 rationalities; it varies according to T, as in a season of risk, which characteristically marks out the pace of decision making for the Adaptor, hence RA; and it varies according to the quasi-evolutionary ∞, of invention, innovation, and Kondratieff waves of those innovations and inventions over the decades (Appendix B).

{Economy}, when thought of in the context of its structure, typically varies significantly over the scale of business cycles (T) and waves of innovation and social change (∞). Certainly, Arthur's subtitle to his book, the "What It Is" of technology, is striking at understanding the economic *structural* change — our $\boldsymbol{\alpha}(T)$ — that co-evolves with the accompanying "How It Evolves" of technology.

{Human Needs-Wants} certainly vary on the time scale of our seasons of risk (T). For what, after all, does the Adaptor do under RA in ERM? S/he swaps out one Basic 4 auto-pilot with *its* liking of the way company performance should be and installs a different auto-pilot with *its* quite different respective, ever-inseparable, and distinctive wants for company performance.

The four systems co-evolve with one another, each with their respective structural changes ($\boldsymbol{\alpha}(T)$), which logically gives us something of the chicken-and-egg problem. But let us start with the "means" side of an economy, with the behavior of each system duly tagged by a time scale(s):

> {“Mobilizable” Resources (t,T)} co-evolve with {Technology (t,T,∞)}, which co-evolves with {Economy (T,∞)}, and both changing technology and economy induce co-evolving {Human Needs-Wants (T,∞)}, which induce in their turn yet more structural change in the economy, technology, and the way resources are deemed “mobilizable”, and so on (and on).

At the heart of this complex of complicated co-evolution, for Arthur (2009), is this: that technology is autopoietic; technology creates itself.

In the complex we may also discern the essences of stability (t), resilience (T), and the quasi-evolutionary (∞). We may extract the simple ball-surface iconography: that the high-frequency dynamics of the ball (t) — somewhere symbolically “in there” in the complex — influence low-frequency co-evolving changes in a companion surface (T); or that, with scales shifted a notch, these latter low-frequency variations, as iconic balls (T), induce very-low frequency changes (∞) in yet another scale of their companion iconic surfaces. Or, going the other way, we may say that these very slow fluctuations (∞) give rise to changes in the patterns of behavior of the very fastest of iconic balls (t) — the “evolutionary about it all”.

Massively complex indeed. But that is not the end of it.

The “Institutional” in Much of This

Returning to our close scrutiny of Figure 3.2, let us home in again on the comparator junction (symbolized by Σ) in the lower Strategy segment of the Figure. Two variables meet at this junction, conceptually one on either side of the balance between what the insurer is “getting” and what it is “wanting” of its operations. On the “get” side of the balance we have the $\boldsymbol{y}$, behind which stands the concept of “means”, behind which in turn stand the “actuarial decision-making technology” and the “mobilizable insurer resources”. On the “want” side of the balance we have the $\boldsymbol{y_w}$, behind which stands the concept of “company wants”, conditioned upon the wider “human needs-wants”, which are themselves conditioned upon a utopia residing in the intellectual, if not spiritual world. Or, at least, we might say that if the “economy” — which reconciles means with ends or uses means to reach ends — inhabits “this concrete world”, then utopias are “not of this concrete world”.

When expressed in the framework of control engineering, the plural ways of economizing of Thompson (2010) boil down to the essence of reconciling the $\boldsymbol{y}$, the consequence of the means, and the $\boldsymbol{y_w}$, as the consequence of utopia: two variables; or, as Thompson describes them, two degrees of freedom. The four respective ways of economizing for each of the Basic 4 rationalities may be defined as follows:

> *Pragmatists* have no degrees of freedom. They are entirely unable to dislodge either the $\boldsymbol{y}$ or the $\boldsymbol{y_w}$ from what it will turn out to be.[32]
>
> *Managers* have one degree of freedom. It is within their capacity to change what the company gets, $\boldsymbol{y}$, but not what it wants $\boldsymbol{y_w}$. In other words, algebraically, they strive to achieve $\boldsymbol{y}(t) = \boldsymbol{y_w}$ as nearly as possible, and at all times t.

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[32] This seemingly unappealing attribute of Pragmatists derives from the same original cultural theoretic logic the Pragmatists of the risk-coping realm share with what have been labelled the social anthropological (Durkheimian) solidarity of “fatalists”. Yet the very cross-disciplinary translation of PR from the realm of social anthropology to that of ERM, not to mention that of ecology, is revealing distinctly positive attributes of the Pragmatist’s outlook on the world (see, for example, Beck *et al*, 2020).

> *Conservators* have but one degree of freedom too. In contrast to the Managers, however, they accept that the mobilizable resources are finite, very limited, scarce indeed, and philosophically *not* within their desire or capacity to change. Instead, they exercise their avowed capacity to reduce their wants $\boldsymbol{y_w}$ over time (t), such that eventually these wants are brought below the fixed resources, hence $\boldsymbol{y}(t) \geq \boldsymbol{y_w}(t)$, for all t ... and T and ∞.
>
> *Maximisers* have two degrees of freedom, to change both $\boldsymbol{y}$ and $\boldsymbol{y_w}$. However, according to the non-satiety requirement of Neoclassical Economics — that "people will always prefer a larger basket of goods to a small one" (Rayner, 2010) — they elect only ever to *increase* the company's wants $\boldsymbol{y_w}$, never to reduce them.[33] In the dry, abstract algebra of control engineering (and Figure 3.2), they are ever seeking to achieve $\boldsymbol{y}(t) = \boldsymbol{y_w}(T)$, with the $\boldsymbol{y_w}$ ever growing.

That much (enjoying the two degrees of freedom) the blueprint for the Adaptor rationality will share with the Maximiser, but no more. Separated and contrasted again with the Basic 4 rationalities, therefore, we have the following for the Adaptor's way of economizing:

> *Adaptors* may exercise the capacity to alter the means ($\boldsymbol{y}$) and the wants ($\boldsymbol{y_w}$), and indeed with the complete freedom to increase or decrease both. In particular, given the Adaptor's logical alignment with the hermit rationality of Cultural Theory (Thompson *et al*, 1990; Thompson, 2008), it is not hard to align her/his way of economizing with the notion of renouncing (worldly) wants, hence subsisting most frugally on the barest minimum of resources. In other words, both the $\boldsymbol{y}$ and $\boldsymbol{y_w}$ are brought down towards "zero" over time (t and T).

There is a bigger social and economic picture in which the Adaptor's way of economizing can helpfully be placed. The basic hypothesis of the idea of "social malleability", upon which *Cultural Theory* (Thompson *et al*, 1990) is founded, is this — to quote now from Thompson (2010; p 133):

> that whether a person is able to manage his needs and his control over resources depends on the way in which he is caught up in the process of social life. Po Chu-I, for instance, was not able to prefer a smaller bundle of goods to a larger one until he had withdrawn from the sort of social involvements that went with his privileged yet demanding life as a mandarin — in his case, a regional governor.

Po Chu-I, therefore, had earlier in his life had a career in pursuit of the Manager strategy, before renouncing (note the word!) worldly wants and retiring to a life, in effect, as a hermit. That said, Thompson proceeds to conclude as follows (Thompson, 2010; p 135):

> We should be careful not to demonize scarcity. ... But markets and hierarchies — the standard duo in institutional economics, and in much of political science theorizing — are only two out of the five forms of social solidarity: the five ways of economizing ... And it is important that the other three are not squeezed out of the picture ... So, it is not scarcity *per se* that we need to worry about; it is when the scarcity-based arguments and policy

[33] Both Rayner (2010) and Thompson (2010), upon which we are drawing here, are contributions to a collection of criticisms of the foundational concept of scarcity of resources conventionally associated with Neoclassical Economics. They appear in the book *The Limits to Scarcity* (Mehta, 2010).

> decisions go uncontested — when the voices of the likes of Po Chu-I, Keynes and Blake are silenced — that the little red warning lights should start blinking.

It is thus on the basis of these two extracts from the bigger picture that we now make a further crucial assertion about the Adaptor's strategy of decision making, which again emphasizes what we have referred to as the strategy's exceptionalism. But first, we must address this question: What should constitute the utopia of the Adaptor? Our provisional response, for the purposes of our preliminary blueprint of the Adaptor's strategy is this, that:

> The Adaptor should renounce the gauging of wants in the domain of the company's operational performance $\boldsymbol{y}$ and — taking very good note of the metaphor of a dashboard with blinking red warning lights — elaborate a utopia within the domain of our crucial control theoretic device of time-varying parameters $\boldsymbol{\alpha}(T)$.

This will be the culmination of our new results from this project, in Section 3.3.4, subject to one passing observation on how all of the above relates to the original motivation of the research of this final part of our project, in the IFoA report on "Economic Thought and Actuarial Practice" (Clacher, 2019). Consider therefore the following play on the words of that report's title.

Actuarial Decision Making and the Economic Thinking of IEE

To reform and re-express IEE, now in this final segment of this project, we have drawn upon the Evolutionary Economics of Arthur (2009) and the Institutional Economics of Thompson (2010). Yet at the heart of the resulting compound of the four co-evolving systems ({"Mobilizable" Resources}, {Technology}, {Economy}, {Human Needs-Wants}) and the five ways of economizing, stands the focal element of *actuarial decision making and its variability over time*. What is more, we are asserting that the strategies of such decision making vary over each of the overlapping measures of the short, the long, and the quasi-evolutionary scales of time: of respectively t, T, and ∞.

The IFoA Clacher Report, as a frame of reference, is gathered around a small sample of interviews with actuarial professionals and economists. It addresses *inter alia* four themes of special relevance to our present project. First, there is *economic pluralism*. Second, there are the challenges flowing from the "*mathematizing*" of a subject, notably that of financial economics. A third key theme is that of the distinction between happenings and behavior in the short and the long term, i.e., *time and system dynamics* — in effect, our distinction herein between micro time t and macro time T. Fourth, there is the continuing significance of the distinction between *risk and uncertainty*.

We respond to just the first three of Clacher's four themes, with two quotes from the Report. The first is this (Clacher, 2019; p 8, with emphasis added):

> The core message from this paper, and the most important result of the work, is that *economic plurality* is the defining characteristic of well-applied economic understanding. Economic theory is simply that – theory. It is a *way of viewing the world*, and so to use *only one lens* for all economic problems or the same economic problem can, through time, have unintended consequences. A broadening out of the way in which the profession uses economics is therefore needed.

The pluralism to which Clacher is referring here is, we (strongly) suspect, not the same as that in the fivefold rationalities of our theory of Plural Rationality, whose logical organization is quite specific.

Second, although enfolded into other matters of significance, the importance of the split in temporal outlooks — short *contra* long — is expressed most clearly as follows (also on page 8 of the Clacher Report):

> [F]inancial economics was useful and remains so in several contexts. However, over-reliance on markets and mathematically tractable models may be making long-term institutions short-term in their outlook, giving a false sense of security to firms and to regulators and skewing long-term investment in the real economy.

For our purposes — of considering variability in decision strategy as a function of time — we have equated the dichotomy with that between behavior in the short term and behavior over the long term. It is as that between relatively fast changes in micro time (t) and relatively slow changes over macro time (T), if not the very (very) slow of the quasi-evolutionary time (∞), of business cycle after business cycle (and so on). The dichotomy is also as that between the systemic dynamic property of stability (t) and the systemic property of resilience (T,∞). It is as that (in terms of plural rationality) between temporal fluctuations *within* a season of risk (t) and change marked by the *transitions* from one season to another (T). Which last is indeed the very thing that calls for Rational Adaptation in ERM.

The exceptionalism of the Adaptor (as yet *integral* to IEE nonetheless) is apparent in that this fifth rationality has no favored season of risk. For the Adaptor the seasons come and go. Navigating with aplomb through all of them — insurance-business cycle after insurance-business cycle and into the distant future — is what counts. And that navigation must be alert to the Adaptor somehow *not* being caught up in the playing out of the social-power dynamics among the Basic 4 rationalities within the company, which may occasion "erroneous" flips among the four risk-coping strategies, even *within* a given season of risk.

So, what exactly is this elusive thing called resilience, that Myth of Nature to which the Adaptor holds; and how might we acquire more of it in company operations — if an insurer deems it desirable — day-in day-out, year-in, year-out, and ever onwards into the longer-term future?

3.3.4 ORGANIZATIONAL AND DESIGN DECISIONS FOR ENHANCING COMPANY RESILIENCE

A quarter of a century on from his seminal 1973 paper on stability and resilience, Holling co-authored a paper on "Ecological Resilience, Biodiversity, and Scale" (Peterson *et al*, 1998). One of the paper's section headings is salient: "Models of Ecological *Organization*" (Peterson *et al*, 1998; p 7, with emphasis added). The paper develops and proposes a synthesis of the four key earlier models — Darwin/Macarthur; idiosyncratic; drivers and passengers; and rivet[34] — from which these further insights are then drawn (Peterson *et al*, 1998; pp 16 and 13, respectively):

> [E]cological resilience is generated by diverse, but overlapping, function within a scale and by apparently redundant species that operate at different scales, thereby reinforcing function across scales.
>
> The combination of a diversity of ecological function at specific scales and the replication of function across a diversity of scales produces resilient ecological function.

Our interest (and that of our Adaptor *A*-type) is in the organization of an insurer, for which we need to introduce two tentative, but crucial, cross-disciplinary conceptual equivalences. Think, therefore, of the insurance company as an ecosystem; think too of the upholder of a given risk-coping rationality in the company as a biological species. And, to continue, let us equate the mission-critical "function" of the

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[34] This rivet model is cited by Martin and Sunley (2015) in their rather comprehensive work on resilience in regional economic systems, in particular the "bounce forward" aspect thereof, as opposed to mere "bounce back". The former roughly equates with that of greatest interest here, namely ecological resilience, as opposed to the engineering resilience of the latter (see Holling, 1996).

system in the foregoing quote from Peterson *et al* (1998) with the risk-coping tasks discharged by the ensemble of all the company's decision-influencers.

In the Social World: Requisite Variety and Duplication of Rationalities and Roles

First, therefore, the enduring viability of each of the Basic 4 rationalities may be deemed indispensable to resilience (of the ecological variety) in the company's behavior. The loss of viability of any one of them, or extinction of any one of them — because the unfolding of the company's social-power dynamics causes the membership of any one rationality (grouping, solidarity) to decline towards zero at any time (t) — would therefore undermine resilience in the company's performance (over T and ∞). An imagined four-light dashboard panel upon which the Adaptor gazes — from within her/his Rational Adaptability block in the Adaptation segment of Figure 3.2 — should show none of those "blinking red warning lights" of Thompson (2010), only steady greens (or steady, not blinking, oranges). In which case, we conjecture, the time-varying parameters $\boldsymbol{\alpha}(T)$ in the domain of the Adaptor's utopia could be the colors of the four dashboard lights, with the pursuit of all-green being the Adaptor's "want"; and with her/his interventions then prompted by any non-green status of any one (or more) of the lights.[35]

Second, more subtly if not more completely — yet palpably and quite deliberately apparent in practice (as we shall soon see) — each employee can be said to exhibit a *personality* with a specific *role*, a specific mission-critical function, that is, which they discharge for the company as a whole (ecosystem like). A more refined warning-light system may be conceived. The argument supporting this proposition runs as follows. Our four seasons of risk in ERM map one-to-one across to the four isomorphic phases in the development and renewal of an ecosystem, according, that is, to Holling's so-called adaptive eco-cycle (Holling, 1986; see also Thompson, 2008). A corresponding "adaptive social system" can be mapped onto the eco-cycle (Fath *et al*, 2015); and 12 personality types, each with their personality-specific roles and functions, can be plotted as tailored to contributing to the social resilience of the system at various points in time around the four phases of the cycle (Katzmair, 2019). Indeed, some types are especially well suited to enabling the system to escape various "social traps" coincident with what we would describe as the transitions between seasons of risk. The 12 personality types may therefore be distributed logically among the Basic 4 rationalities, such that a 2-D array of warning lights can be imagined on the Adaptor's dashboard. And again, we may invoke the green-orange-red color scheme (with flashing options) for numbers of employees occupying each rationality-type slot.

To give practical effect to such a scheme, there is a spin-off company in Vienna called FASresearch (https://www.fas-research.com/about-us). It has been engaged in building and enhancing resilience in the affairs and performance of an innovation ecosystem on the site of the former Tabakfabrik in Linz, Austria. At any point in time, the challenge to be met is this. Is the "inventory" of employment niches in all the constituent businesses of the entire ecosystem replete with the requisite spectrum of personality types (hence rationalities) for serving the goal of resilience? If not — because some of the niches are no longer occupied by the requisite personality type (they have gone extinct) — then someone (in a notional human resources department for the *entire* ecosystem) needs to act: to recruit prospective employees with the right personality traits to fill the empty slots. That "someone" should, of course, be the archetypal Adaptor

[35] This merits two qualifications. First, intuitively (even for actual practice), the color of any light might be geared to the respective numbers of insurer employees adhering at any given time to each of the Basic 4 rationalities. In which case, in control engineering terms, the four numbers could be said to be something like the four state variables of the company's social world, as the social-power dynamics among them play out, with indeed, more than one rationality member fulfilling the desirability of the "duplication" and beneficial "redundancy" of agents discharging system-wide mission-critical functions. Second, none of the rationalities simulated in the Surprise Game technically become extinct, i.e., with zero membership, at any time (Ingram *et al*, 2012).

of the fifth rationality. In practice, in the Tabakfabrik ecosystem, the founder of FASresearch, Harald Katzmair, approximates such a type (something he wisely neither confirms nor denies!).

In the Material World: Requisite Variety and Duplication of Systemic Dynamic Properties

There is an important word — it is "scale" — in the definition of resilience of Peterson *et al* (1998) quoted above. We now attempt to benefit from this attribute, although not so much in the sense of the volume of an economy or the scope of a financial asset. Rather, we focus on scale as manifest in time, including our trio of three scales t, T, and ∞. To do so, we begin by citing the mouse and moose (whose alliteration, one suspects, did not escape the notice of Peterson and colleagues). Both species of animal discharge at least two mission-critical functions for the well-being of a wetland eco-system: seed dispersal and nutrient renewal-redistribution, both realized through their respective metabolisms. But of course, the dynamics of one of them (the mouse) are a matter figuratively of a fast, high-frequency, frenetic buzz; whereas the dynamic behavior of the other is a slow, ponderous, low-frequency rumbling.

The mouse and the moose are present and thriving in the wetland ecosystem as a result of complex co-evolution unfolding over the eons according to *no* particular pre-ordained plan. In contrast, a portfolio (ecosystem) of company assets (species) may be designed, assembled, and operated at the will of the company. In matters of a system's dynamics, control is the branch of engineering that takes these dynamics as they are and re-engineers them, through the device of a controller, so that they are more to *our* liking. Control engineering, to recall, delivers the smoothness and comfort we all appreciate in the flight of the modern passenger plane. But the "our" is emphasized because PR allows for five distinctive "ours" and five distinctive sets of company wants. According to PR and IEE, therefore, there can be five ways of designing, assembling, and (season-in, season-out) operating the company's portfolio, to serve one or more of the company's mission-critical tasks. This includes therefore the uncomfortable prospect of, say, a Maximizer design of portfolio having subsequently to be operated by a Pragmatist, as the seasons of risk turn.

How might the design and assembly of an initial portfolio of company investments be guided in order to serve long-term company resilience, prior to its operation? If we were to follow Peterson *et al* (1998), we should need to achieve pretty much what the above definitive quote says, but with ecosystem replaced by portfolio and species by financial assets. What precisely might then be the portfolio's mission-critical function(s) for the company — for the *long* term as much as the seasonal and the short term — we shall leave undefined, but trust that a book such as Silver's (2017) *Finance, Society and Sustainability* would assist in its eventual elaboration. In this culmination of our blueprint for the Adaptor strategy in ERM we offer just the very beginnings of some possible considerations for the design and operational delivery of resilience in an investment portfolio.

Noting thus the markedly differing dynamic attributes of the mouse's and the moose's responses to the disturbances and opportunities ($\boldsymbol{d}$) impinging upon them in their wetland ecosystem, we shall offer just the brevity of the following with regard to the selection of assets and the assembly of the portfolio. Whatever ends up as the wants, $\boldsymbol{y}_w(T)$ for the actual, eventual performance of the portfolio of assets over all time, $\boldsymbol{y}(t;T;\infty)$, each constituent asset in the portfolio should ideally have its own respective and distinctive set of intrinsic, systemic, dynamic attributes. They are its "systemic dynamic" parameters $\boldsymbol{\alpha}$. In the vocabulary of control engineering, they are called time constant, damping factor, natural frequency, dead-time, and so on. The dynamics of a mouse of an asset, for instance, might be parameterized, in effect, as having no dead time, a small (very fast) time constant, a low damping factor, and a high natural frequency.[36] And the whole point in delivering long-term resilience in portfolio performance according to the definition of Peterson *et al* (1998), is that the constituent dynamics of each separate asset should be parameterized (in these terms) so as to cover features such as diversity, duplication, and redundancy of portfolio functions within and across scales of asset, not least in respect of their characteristic dynamic properties.

Conspicuous by its absence from this design of the portfolio is our core idea of these systemic dynamic parameters being capable of exhibiting variation over time — of being not only "systemic dynamic" parameters but also "time-varying" parameters, i.e., some more of the $\boldsymbol{\alpha}(T)$ (hence the difficulties here in minimizing confusion in our wording). After all, it was for one such parameter, a time-varying damping factor, for which Diks *et al* (2015) and Rye and Jackson (2016) were searching in their analysis of long-term national GDP time-series.

But this re-introduction of $\boldsymbol{\alpha}(T)$ also marks the distinction between the prior *design* of the portfolio and its subsequent *operation*, through company decision strategy: first, not least according to some proposed model of variability in actuarial decision making; second, specifically in the pursuit of resilience over the longer-term, through reserving decisions in the controller (K) block of Figure 3.2; which decisions, third, might be guided (in part) by diagnostic evidence about these time-varying, systemic dynamic parameters $\boldsymbol{\alpha}(T)$ of each constituent asset (of the mouse-like, the moose-like, and so on); and, fourth, which evidence, once more, ought to fall within the province of diagnosis by the Adaptor, for example along the lines of the foregoing proposition of something akin to a "best current snapshot" of the structure of an asset's dynamic behavior.

Last, if the mouse and the moose have evolved in the absence of any plan of Nature, to participate thus in a co-evolved wetland ecosystem (our understanding of which we seek here to benefit from), so too has the endotherm species of warm-blooded creatures (ourselves included). In drawing the distinction between the (superior) ecological and (inferior) engineering kinds of resilience, Holling (1996) has pointed out how endotherms operate at body temperatures perilously close to lethal maxima. And they do so by virtue of the *soft* duplicative redundancy in the endotherm body's multiple (five) ways of discharging the creature's mission-critical function of cooling. The qualification of "soft" here signals the fact that (for Holling) none of the five biological mechanisms discharge their task in a notably efficient technocratic-like or economic manner.[37]

Could there be something to be learned from this, for the purposes of actuarial decision making? Consider, for example, our point of departure into control and systems thinking, Figure 3.1. Home in one last time on the comparator junction (Σ). Imagine now not one but four arrows emanating from the junction, each feeding into its respective parallel controller (K) block, with then the four constituents of the decisions ($\boldsymbol{u}$) emerging from their four respective controller blocks and being applied back to the input side of the insurer's (S) block operations. Fine for an endotherm, we might say, but not for Plural Rationality and Rational Adaptation in ERM in an insurer: because PR is about just the *single* correct feedback controller for the single correctly diagnosed season of risk. But then Holling (1996) does not tell us whether all five

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[36] The dynamics of the climate system, we can say, have a very slow and very long time constant, if not quite a long dead time before their consequences are palpable. It was the dead time in claims processing that required the introduction of feedback control for the stabilization of an insurer's financial performance in Balzer and Benjamin (1980).

[37] For completeness, two things should be noted in passing. First, Holling (1996) observes how the "tightest" of internal operational control "at the edge of chaos" (his words) enabled the endotherms to acquire an evolutionary advantage in exploring their external worlds for opportunity. Second, and perhaps exceptionally so, he writes in admiring terms of the astounding operational feats of modern military aircraft, whose designs are inherently unstable, yet the control (re-)engineering of which bestows a previously unrevealed possibility space of aerodynamic behavior — once off the ground and in the air.

cooling mechanisms in the endotherm's body are always operative in parallel in all seasons. And the empirical evidence from ERM in practice — in the results of Section 2 of this report, as well as over the turns of the insurance cycle of Underwood and Ingram (2013) — reveals that something from two or more of the Basic 4 rationalities is evident in hybrid forms of actuarial decision making.

An Altogether Different Genre of Assets?

The thing about the constituent assets in which insurers can currently invest is that the range of systemic dynamic parameters (α) their behavior over time covers is not conducive to the attaining of resilience in financial performance over the long term. This, we note, is abundantly clear in Silver (2017), albeit expressed in quite different terms. A relevant question, therefore, is whether this might ever change. In composing (again) but a modest response to this question, we hesitate to observe anything about "living in unprecedented times", since each generation no doubt holds this to be so. And yet, there *is* climate change; and now we are reminded of pandemics.

In 1998, therefore, Thompson and Rayner (1998) gave us much of the definition of the "institutional" parent of the Institutional Evolutionary Economics (IEE) of Section 1 above in the monumental four-volume *Human Choice & Climate Change* (Rayner and Malone, 1998). A decade later, Arthur (2009) gave this closing part of our report, in particular, the temporal dimension of IEE as inherited from its second parent of Evolutionary Economics. Yet in Arthur's *Nature of Technology* any reference to the Nature of the environment and climate was confined to the very beginning and very ending pages of the book.

Between the two ends of Arthur's book, we would like (in due course) to place the following three recent developments, each of which on its own might contribute to the emergence of a new genre of investment asset, with, in particular, some *novel* systemic dynamic parameters (α) enabling overall a more resilient operational performance of an insurer's portfolio. This threesome has the following form:

> The principles of *Investing for Resilience*, as enunciated in a Cambridge Institute for Sustainability Leadership (CISL) report under its Climate Wise (Insuring a Sustainable Future) program, authored by IFoA's current (2021) President Louise Pryor (CISL, 2016). The object of the investing to which the report refers is urban infrastructure.
>
> The notion of "Cities as Forces for Good in the Environment" (CFG), including climate repair and mindful of a significantly elaborated version of the (perhaps already forgotten) principles of the Triple Bottom Line (Beck, 2011; Beck *et al*, 2013; Thompson and Beck, 2014; and Villarroel Walker *et al*, 2014, 2017).
>
> Incorporation of the institutional embeddedness of Plural Rationality (and IEE) into the co-evolving technology and economy of Arthur's (2009) arguments.[38]

[38] As a result of this present project, we now see the proceedings of a 2019 Workshop on "How Engineers Think" — in an institutionally embedded manner — as underpinning such a future development. The Workshop, notably, was co-sponsored by the Institute for Science, Innovation and Society (InSIS) at Oxford University and the U.K. Collaboratorium in Research on Infrastructure and Cities (UKRIC).

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Appendix A: Plural Rationalities and ERM[39]

Corporations and the people who run them have their own views of risk and risk management. These perspectives have formed over time, in response to personal and firm experiences, by current risk-taking capacity, by the changing business environment, and through being influenced by watching various strategies succeed or fail. Studies show that risk perspectives fall into four broad groups with almost wholly incompatible views—and only one of those four perspectives is totally compatible with the current paradigm of Enterprise Risk Management (ERM). If proponents of ERM do not offer approaches that make sense for each of the four risk perspectives, ERM can and will fall out of management favor as it did in many firms during the boom heading up to the financial crisis of 2008-9.

A.1 FOUR DIFFERENT PERSPECTIVES ON RISK

The four basic risk perspectives were first discovered in the practical experience of the insurance industry in the context of research that was not originally seeking to study risk attitudes. But clear patterns emerged in the data and have proved quite resilient over time. Most people tend to identify with one of the following perspectives:

Maximizers. This perspective does not consider risk to be very important—profits are important. Businesses managed according to this perspective will accept large risks, so long as they are well compensated. Managers who hold this perspective believe that risk is mean reverting—gains will always follow losses—and the best companies will have larger gains and smaller losses over time.

Conservators. According to this perspective, increasing profit is not as important as avoiding loss. Holders of this view often feel that the world is filled with many, many dangerous risks that they must be very careful to avoid.

Managers. Careful balancing of risks and rewards is the heart of this perspective. Firms that hold this view employ experts to help them find risks offering the best rewards, while at the same time managing these risks to keep the firm safe. They believe that they can balance the concerns of the first two groups, plotting a very careful course between them.

Pragmatists. This perspective is not based on a specific theory of risk. Pragmatists do not believe that the future is predictable—so, to the greatest extent possible, they avoid commitments and keep their options open. They do not think that strategic planning is especially valuable, but rather seek freedom to react to changing conditions.

Each of the different perspectives leads to a strategy for dealing with risk. Firms led by Maximizers seek out risk, believing that no risk is inherently unacceptable—every risk presents an opportunity, and the trick is to negotiate appropriate compensation. Conservator firms shun risk of all sorts. Manager firms carefully manage and calibrate both the amount and type of risk. Pragmatist firms seek diversification but otherwise have no overarching strategy— they operate tactically, reacting to each new development.

[39] Adapted from Ingram, Underwood "The Full Spectrum of Risk Attitudes" The Actuary, August/September 2010

A.1.1 RESISTANCE TO THE CURRENT ERM PARADIGM IS INEVITABLE

The ERM paradigm currently touted as the solution to all risk problems comes straight out of the Manager playbook. ERM helps firms with a Manager orientation to do a better job at what they were trying to do anyway.

But, given the four fundamental risk perspectives (and various hybrids thereof), it is hardly surprising that adoption of ERM has been less than universal and often less than enthusiastic. No matter how reasonable ERM sounds to its Manager-oriented proponents, it does not align as well with other risk perspectives. In many cases, managers are only pretending that ERM is their new management program.

For example, Maximizer firms see ERM as an unnecessary restriction. Why should a limited risk appetite be enforced, when any risk can be accepted for the proper price? That means turning away potential profit! If a Maximizer firm bows to outside demands for ERM—such as those imposed by a rating agency or regulator—this may be largely a charade, a sop to the unrealistic pessimists and worrywarts.

For Conservator firms, ERM is a dangerous strategy because it encourages taking more risk. Establishing a risk appetite would only give permission to the cowboys in the ranks to expand risks to fill that risk budget. While such a firm may—with trepidation—adopt an ERM program, Conservator executives remain convinced that risk assessments can never be comprehensive enough; risk quantification cannot be trusted because the result is always too low.

Pragmatic firms do not trust risk assessments either. But they are not sure whether the existing assessments are too optimistic or too pessimistic. Adherents of the Pragmatist perspective think that ERM takes too constant a view of an ever-changing world. In their minds, ERM means letting a model run the company. And a fixed set of rules and metrics hampers their ability to react to changing circumstances.

In a world of multiple risk perspectives, a Manager-only approach to ERM is as self-limiting as an auto manufacturer that offers “any color you want, as long as it’s black.”

A.2 ERM NEEDS A BIGGER TENT

The truth is, risk management in one form or another has been practiced since the dawn of time—by adherents of all of the four basic risk perspectives. And it would be difficult to argue that adding an enterprise-wide view to any risk management strategy is not beneficial. A broader and more flexible definition of ERM would bring more managers and more firms “into the tent,” enabling the benefits of an enterprise-wide view of risk to be realized more broadly.

Careful examination of risk management practices in a large number of financial and non-financial firms reveals that there are four different strategies that fall under the general heading of risk management:

Loss Controlling. This is the most traditional form of risk management; indeed, it pre-dates ERM. It seeks to identify and mitigate the firm’s most significant risks. Commonly practiced by nonfinancial firms, Loss Controlling also applies to financial risk; examples include the careful underwriting of loans or insurance policies, as well as the practice of claims management. Risk management of this sort is not new—but the inclusion of an aggregate, firm-wide view of risk is a relatively new development that could be termed Loss Controlling ERM. This type of ERM is favored by Conservator firms.

Risk Trading. A newer form of risk management, this approach arose from bank trading desks and the insurance industry. Risk Trading focuses on getting the price of risk correct— which leads to sometimes complicated models of risk, reward and economic capital. While a Risk Trading strategy can be applied on a transaction-by-transaction or other "siloed" basis, establishment of a consistent risk valuation on a firm-wide level is Risk Trading ERM. This type of ERM is favored by Maximizer firms.

Risk Steering. Under this strategy, the ideas of Risk Trading are applied at a macro level to the major strategic decisions of the firm. Here, rather than focusing on the proper price of risk, the question becomes one of how much risk the firm should take—and how to steer the firm in that ideal direction. By its very nature, this is an enterprise-wide approach. Perhaps this is why some seem to think that only Risk Steering ERM is "real" ERM. Risk Steering ERM is highly favored by academics and consultants; Manager firms find it appealing, but firms that hold any of the other three strategies do not.

Diversification. Spreading risk exposures among a variety of different classes of risks, and avoiding large risk concentrations, is another traditional form of risk management that pre-dates contemporary ERM. Formal diversification programs will have targets for the spread of risk with maximums and minimums for various classes of risks. The newer ERM discipline adds the idea of interdependencies across classes, providing better quantification of the benefits of risk spreading. Pragmatists tend to favor diversification because it maximizes their tactical flexibility, but they avoid reliance on any particular risk mitigation process and often mistrust quantitative measurement of diversification benefits.

We believe that limiting the field of ERM to Risk Steering ERM alone would be a serious error. Such a restrictive definition of ERM would alienate firms and practitioners holding any of the other three risk perspectives[40]. Moreover, such a limited view is inherently incomplete, for reasons that the Pragmatists know all too well.

Simply put, the world does not stand still.

A.3 CHANGING RISK ENVIRONMENTS

Why do different people prefer different colors? That's a difficult question, influenced no doubt by personality, individual differences in color perception, and early experiences and associations. The existence of the four different risk perspectives may be easier to explain—and clearly a key factor is that, over time, the risk environment changes.

A simplistic model of changes in the risk environment might posit that either things are "normal" or they are "broken." But people do not necessarily agree about what is "normal." An observer viewing the world through the lens of Conservation might say that extreme hazard and danger are the "normal" state of affairs—while a Maximizer, finding this view timid and overly pessimistic, might argue that profitability is "normal" and hazardous conditions prevail only when the market is "broken."

Expanding the model to allow more than two states allows for the possibility that both the Conservation view and the Maximizer view can make sense. Consider a world with four risk regimes:

1. **Boom**. Risk is low and profits are going up.
2. **Bust**. Risk is high and profits are going down.

[40] We found that only 17% of insurance industry managers held a pure Manager point of view, while another 45% hold a hybrid view of Manager with one of the other three risk attitudes who may or may not agree with the ERM approach to risk. That leaves 38% without any belief in the Manager paradigm. Ingram, Thompson, Underwood All on the Same Train, Intelligent Risk (2014).

3. **Uncertain**. Risk is very unpredictable; profits might go up or down.

4. **Moderate**. Both risk and profit fall within a predictable range.

Such a model seems to be a reasonable description of economic cycles—whether in the banking world, the insurance sector or the broader economy. As the cycle moves through these four different states, external conditions match the worldview of each of the four different risk perspectives. Each perspective has been correct part of the time—and will be again, at some point in the future. But none of the risk perspectives is perfectly adapted to external conditions all of the time.

Purists with the Manager point of view may object that their view takes into account the full range of the cycle. But economic cycles are not sine curves; the period and amplitude are irregular, unexpected "black swan" events do occur, and there are always "unknown unknowns." Model risk can never be eliminated, and restricting ERM to a Manager-only view obscures this important fact. Moreover, nothing says that Bust must follow Boom or that Moderate must follow Uncertain.

A Risk Steering ERM program works especially well in the Moderate risk environment when risks are fairly predictable. But in a Boom environment, firms following such a program will unduly restrict their business—not as much as Conservator firms, but certainly more than Maximizer firms—and more aggressive competitors will be much more successful. In the Bust environment, a Risk Steering ERM program again advocates a middle path; this may mean the firm sustains too much damage to be positioned to take full advantage of the market when it turns. When times are Uncertain, a firm following a Risk Steering ERM program will be frustrated by frequent surprises and a world that does not quite fit the model. Competitors not tied to a particular view of risk will fare better, making decisions in the moment with maximum flexibility.

Why then do corporations adhere to a particular risk perspective? The firm may have been formed during an environment aligned with their perspective. Alternatively, the company may have suffered traumatic damage during a period of dissonance between an old perspective and the risk environment and then made a shift, perhaps under the direction of new leadership. The firm may have been wildly successful at some point in the past, and now clings stubbornly to the strategy that worked for them then. Corporate culture tends to be self-perpetuating: individuals are drawn to employers with a perspective that makes sense to them—and those in a position to make hiring decisions typically prefer to hire staff whose views mesh with their own.

In any given risk environment, companies holding a risk perspective and following an ERM program aligned with external circumstances will fare best. (See Table 1)

Yet in each risk regime, there are companies following strategies that are not well aligned with the environment. Some of these firms muddle along with indifferent results according to their own stance on what constitutes success and survive until their preferred environment comes back. Others sustain enough damage that they do not survive; some change their risk perspective and ERM program to take advantage of the new environment. Meanwhile, new firms enter the market with risk perspectives and ERM programs that are aligned with the current environment.

Since many of the poorly aligned firms shrink, die out or change perspective— and since new firms tend to be well-aligned with the current risk regime—the market as a whole adjusts to greater alignment with the risk environment via a process of "natural selection."

Table A.2

RATIONAL ADAPTABILITY: ALIGNMENT OF ATTITUDE, ENVIRONMENT AND STRATEGY

Risk Attitude	Maximizer	Conservator	Pragmatist	Manager
Risk Environment	Boom	Bust	Uncertain	Moderate
Risk Management Strategy	Risk Trading	Loss Controlling	Diversification	Risk Steering

So far, four attitudes, Environments and Strategies have been identified. There is a fifth that is based upon the risk attitude of being aware of and open to all four of the basic four risk attitudes and all four of the possible risk environments. The risk management strategy of this fifth risk attitude is called **Rational Adaptability**. This involves three key steps:

1. Discernment of changes in risk regime,
2. Willingness to shift risk perspective, and
3. Ability to modify ERM program.

The difference between Rational Adaptability and the process of "natural selection" described above is conscious recognition of the validity of differing risk perspectives and proactive implementation of changes in strategy.

This risk perspective is called **Adaptor**.

Individuals often find it difficult to change their risk perspective. Therefore, a company that wishes to adopt a Rational Adaptability strategy must ensure that its key decision-makers represent a diversity of risk perspectives. Furthermore, the corporate culture and the managers themselves must value each of the risk perspectives for its contributions to the firm's continued success.

An insurance company is best served by drawing on the respective expertise of underwriters, actuaries, accountants, contract attorneys and claims experts—and members of one discipline should not feel slighted when the expertise of another discipline is called upon. Similarly, any firm that wishes to optimize its success under each of the various risk regimes should have Maximizers, Conservators, Managers and Pragmatists among its senior management; and those who hold any one of these risk perspectives should acknowledge that there are times when an-other perspective should take the lead. The CEO must exercise judgment and restraint, shifting among strategies as needed and shifting responsibilities among the management team as required.

Rational Adaptability recognizes that during Boom Times, risk really does present significant opportunities—and it is appropriate to empower the Maximizers, focusing ERM efforts on Risk Trading to ensure that risks are correctly priced using a consistent firm-wide metric. When the environment is Moderate, the firm employing Rational Adaptability will give additional authority to its Risk Reward Managers, examining the results of their modeling and using these to reevaluate long-term strategies. And in times of Recession, a firm following Rational Adaptability shifts its focus to Conservation: tightening underwriting standards and placing special emphasis on firm-wide risk identification and risk control. Resisting the pull of his or her own personal risk perspective, the CEO must be willing to listen—and act—when others in the firm warn that the company's risk management approach is getting a little too focused upon just one strategy.

Appendix B: Four Rhyming Cases: Tulipmania, The South Sea Bubble, 1929 and 2007/8

Here we turn from the vindication of Kondratieff and his much-maligned cycles to four examples of those cycles. These range from brief accounts of Tulipmania and of the South Sea Bubble, in the seventeenth and eighteenth centuries respectively, to more detailed discussions of the two most recent upturns: one culminating in the 1929 Crash, the other in the 2007/8 Credit Crunch-*cum*-Global Financial Crisis. Together, these two historic "classics" and the two recent ones that are still almost within living memory span nearly four hundred years. As we will see, they demonstrate similar structural characteristics – characteristics that are in conformity with Kondratieff's hypothesis – along with recurring similarities in deviant practices, with the definitions of deviance themselves altering in the way we have predicted. Though the methods and instruments used display a remarkable consistency, they have over time developed in terms of both sophistication and scope. Not so much full circle, you might say, as full spiral.

B.1 TULIPMANIA

Tulips had been introduced to northern Europe in the mid-1500s from the Middle East and southern Europe. By the late 1570s they were fashionable at courts and among the aristocrats of France, Germany and England. By the end of the century a taste for them had spread to the richer middle classes of Vienna and Holland, for whom they became a status symbol – a demonstration of their wealth and good taste. As prices rose, collections came to include ever more refined and rarefied specimens. These were graded and classified, and the prices of the rarer ones attracted substantial premiums.

The early to mid-seventeenth century was Holland's Golden Age (see Schama 1997). At the hub of a trading empire with colonies in Asia and America, she had a vast maritime fleet and dominated the lucrative East India trade. She also had a developed banking system that facilitated the creation of credit – though much credit was also supplied by vendors. The trade in tulips, therefore, could readily be fueled by a prosperous middle class with surplus funds accumulated from a rise in prosperity from 1622 and particularly during the first half of the 1630s. Holland was thus well set to exploit the rising demand for tulips, and its soil and climate were particularly conducive to producing them. As trade in tulips in the 1620s extended well beyond its borders, methods of harvesting, storing, packing, transporting and securing tulips had to be developed. A new industry and new specialisms emerged: expert tulip assessors appraised new mutations, insurances were arranged, and the banks undertook large investments in especially designed tulip vaults (Beckman 1990:15-16). The credit they offered became integral to the new industry and to Holland's economy, which became dependent on the trade in tulips. Investments, we can say in retrospect, were being fed, in excess, into just one asset class – tulips – in much the same way that they were piled into domestic property in the years leading up to 2007/8 (see Figure 2.2).

Speculation mounted in the early 1630s. At Tulipmania's peak, prized bulbs were selling for over 4,500 florins and the average price of a single bulb exceeded the annual income of a skilled worker.

> Four fat oxen could be bought for 480 florins while the price paid for the rarest bulb of all, one of only two specimens was 4600 florins, a new carriage, two grey horses and a complete set of harness … Many individuals grew suddenly rich. A golden bait hung temptingly out before the people and one after the other, they rushed to the tulip-marts, like flies round a honey pot. Everyone imagined that the passion for tulips would last forever and the wealthy from a every part of the world would send to Holland and pay whatever prices were asked for them. (Mackay 1993:91)

Beckman (1990:17-18) records a variety of scams during Tulipmania, "Tulip Jobbers … accrued huge profits buying massive quantities each time there was a fall in price and rapidly selling out on every rise." They could do this because of the tight networks in which they operated while simultaneously spreading rumors about the market's inherent stability. More obviously criminal activities also developed:

> … manipulators of the tulip market trained animals to dig up and devour bulbs for the purpose of creating a scarcity of selected strains, thus forcing prices higher. Ducks, cats, geese, pigs, chickens and various other household livestock were turned loose on the multifarious tulip patches to create havoc for the tulip breeder, grower and profits for their owners.

In a foretaste of insider trading, "tulip riggers" emerged who purchased the stocks of a specific grower and then spread rumors of calamitous destruction.

> The price of tulips from the region [would rise]to astronomical heights in anticipation of a permanent shortage of the species destroyed. They would then sell … to unsuspecting buyers preparing for further prices rises.

What later came to be known as rings were established.

> Tulip riggers would form a pool and choose a particular species of tulip that was out of favor … By buying and selling among themselves – the riggers would make it appear that the selected species was suddenly in demand (Beckman 1990:25-6).

They would do this repetitively, moving from one stock to another. But at the mania's peak some dealers, well aware that perpetual upward prices were beginning to appear unsustainable, sold out. As selling mounted, panic took hold and tulip prices dramatically collapsed.

After the crash, as with all crashes, there was a public outcry and calls for regulation and control. In November 1636 the Dutch government ineffectually declared "that all contracts made at the height of the mania or prior to the month of November 1636 should be declared null and void and that after that date purchasers should be freed from their engagements on paying ten percent to their vendors" (Mackay 1993:6).

Tulipmania thus set the scene for our understanding of subsequent crashes. It demonstrated a dependence on a surplus of funds from earlier in the upturn, a ready supply of available credit and a generalized belief that prices would rise in perpetuity. It embraced a network of market manipulators who knowingly encouraged this belief and a refined development of criminal and deviant specialties. Together these contributed to euphoric bidding that rose to a peak and was followed by a sudden crash, a downturn (lasting in this case until around 1650), public outrage and resultant moves for government regulation.

B.2 THE SOUTH SEA BUBBLE

By the early eighteenth century England had eclipsed Holland and was the trading center of the world. Its economy was booming, with a wave of developments in construction and transport, and its trade was supported by the unrivalled power of its empire and its navy. Large profits were simultaneously accruing to its trading companies operating abroad, such as the Hudson's Bay Company and the West and East India Companies. As in Holland a century earlier, England was thus well set to launch a company that offered trading opportunities in the South Seas and beyond.

The South Sea Company's principal asset was a monopoly, granted by the British government in 1711, to exploit the riches of the South Seas (which extended also to South America, the West Coast of North America and onwards to the Far East). It was granted, together with the right to obtain the revenues of certain taxes, in return for accepting responsibility for the national debt – swollen by liabilities in maintaining unmanageably expensive army and navy debentures. These costs were causing mounting government concern because they involved unsustainably high taxes. Since the South Sea Company had explicit government support, the new enterprise seemed to be following the precedent of the lucrative East India Company and it was enthusiastically over-subscribed.

After its launch in 1711, the stock suffered various setbacks but the directors, "by various arts" (Mackay 1993:65) and then with specific government backing, encouraged:

> … the most extravagant rumors [about supposedly emergent treaties] between England and Spain … whereby the latter was to grant a free trade to all her colonies; and the rich produce of the mines of Potosi-la-Paz was to be brought to England until silver should become as plentiful as iron. For cotton and woollen goods, with which we could supply them in abundance, the dwellers of Mexico were to empty their gold mines. The company of merchants trading to the South Seas would be the richest the world ever saw, and every hundred pounds invested in it would produce hundreds per annum to the stockholder (Mackay 1993:51).

In little over the ten years of the company's existence, the enthusiasm of investors had at different times faltered and revived by the spreading of false rumors, by paying, on occasion, double the expected level of dividend, at others by the issuance of new stock, and by the use of "tame" journalists. One such journalist was Daniel Defoe (the author of *Robinson Crusoe*) who, when the shares were at their peak, wrote a journal article "puffing" the price further. It is suggested that he owned shares in the companies he promoted: an early example, it is claimed, that illustrates the later venality of much of the press which had become well established by the time of the 1920s upturn (many later examples of which are offered by Kindleberger and Aliber [2011:146]).

But the exuberance surrounding the South Sea Company had simultaneously encouraged nearly a hundred fraudulent joint stock companies, largely funded by credit and:

> each more extravagant and deceptive than the other … promoted by crafty knaves, then pursued by multitudes of covetous fools, and appeared to be in effect, what their vulgar appellation denoted them to be – bubbles and mere cheats (Mackay 1993:54).

Some bubble companies were established merely with the view of raising their shares in the market. "The projectors took the first opportunity of a rise to sell out, and next morning the scheme was at an end." Some of the schemes were clearly ludicrous. One for instance was:

> for a wheel for perpetual motion – capital one million pounds … another for a company for carrying on an undertaking of great advantage, but nobody to know what it is … it was computed that near one million and a half sterling was won and lost by these unwarrantable practices, to the [eventual] impoverishment of many a fool, and the enriching of many a rogue (Mackay 1993:54-55).

The growth of these more obviously fraudulent companies was soon seen as posing a serious threat to the South Sea Company, since money invested in them was not available to it. When in 1720, the South Sea Company's share price again wavered, its directors sought support from the government – many members of which were shareholders. In 1720 it passed what came to be called 'The Bubble Act' which outlawed companies without a royal warrant. The move was successful and the price of South Sea shares rose to peak at £1,000.

The directors owned significant blocks of shares and were able to collateralize them and use the funds raised to invest in real estate. Their central concern was then to boost the value of the stock to effect a capital gain, and the spreading of rumors was integral to this. The company chairman Sir John Blunt "had six contracts to buy estates … another [insider] had four … on which he owed £100,000". It was therefore necessary to increase capital and the price of stock simultaneously and at an accelerating rate "as in a Ponzi scheme" (Kindleberger and Aliber 2011:14). Despite the company's efforts, the peak price of £1,000 was not sustainable. The chairman, his close associates, various directors and members of the government, well aware the value of their assets was minimal compared to their stated values, sold out. When knowledge of this became public, the stock crashed and soon was worthless.

As with Tulipmania, popular clamor was again raised that "this must never happen again". Mobs rose and pressure mounted on the government to regulate market excesses, which in part it did by outlawing the issuing of stock certificates, thereby abolishing limited liability. This law was not repealed until 1825 and thereby helped inhibit the subsequent recovery.

B.3 THE 1929 CRASH (AND ITS PRECURSOR: THE FLORIDA LAND BOOM)

The 1929 Crash followed a similar progression to its predecessors and exhibited similar (though more sophisticated) behaviors. Its sequence began in 1920-22, with a recession in wholesale prices of 42 percent and a fall in the Dow Jones Index of 33 percent. Similar or worse falls were recorded in France, the U.K. and elsewhere though the markets recovered fairly quickly.

But there was a further portent of disaster when massive speculation in land, based upon exploiting Florida's warm sunshine, led to the Florida land boom and the emergence of Charles Ponzi. As many as 65 building sites per acre, together with streets laid out on sub-marginal land, were offered that were larcenously described as "being on the seashore when they were up to 15 miles inland" or, in Ponzi's sales pitch, described as "being near Jacksonville when they were sixty five miles distant from the city" (Galbraith 1994:62-3). But in their scramble to invest, buyers were not bothered by such detail – they were in the market to speculate, not to reside in Florida. The end, in 1926, was swift: the supply of new buyers ran out and land prices crashed. "Some land having passed through the hands of half a dozen speculators, each reaping the rewards of leverage, was returned, in successive defaults to the original owner … In 1925, bank clearings in Miami were $1,066,528,000. By 1928 they were down to a mere $143,364,000" (Galbraith 1994:64).[41]

But the Roaring Twenties roared on, and a record number of new and inexperienced investors with surplus funds from the prior boom began to gamble on the stock exchange. They focused particularly on the newly emergent industries and technologies dominated by automobiles and radio. As in Holland three hundred years earlier and in England a century after that, financial affairs in this period were

> noted for manipulation and swindling. Interest brokers, blockers, traders and owners banded together to manipulate stock prices by trading them between each other for

[41] Quoting Frederick Lewis Allen, *Only Yesterday* (New York: Harper 1931), p. 282.

> slightly more each time. An ignorant public noticed the trend and invested through credit whilst the manipulators sold at a healthy profit. (Beattie 2012)

Meanwhile the market soared. One important reason it soared was leverage: shares could be bought from brokers "on margin", in anticipation of their imminent rise, for as little as a 10 percent down-payment of the purchase price (though some purchasers were required to offer up to 50 percent). The balance was borrowed from the broker who in turn borrowed from the banks.

Galbraith suggests a second, more sophisticated, example: "closed ended investment trusts" which could effect multiple levels of leverage – and which, when they crashed, involved multiple scales of de-leverage. These trusts were pioneered by Goldman Sachs in 1928 when it created a company, Goldman Sachs Trading Corporation, the sole function of which was to own other companies' stock. It issued securities amounting to $100 million (a billion dollars at 1994 prices), 90 percent of which were sold to the public, with 10 percent being retained by Goldman Sachs. The Trading Corporation issued common stock, bonds and preferred stock. The latter two had fixed returns that did not rise with the price of the stock so that all gains accrued to the price of the common stock. Goldman Sachs then sponsored a further company (whose initial issue was said to have been over-subscribed seven-fold) and that company sponsored yet another. All the intervening companies in their turn issued the three types of security. The large gains in the stock of the final company soared as its holdings boomed and these went "in powerful concentrations" to add to the stock of the intervening companies until it was fed into Goldman Sachs (thereby anticipating the nickname – "the Vampire Squid" – that it was to have pinned on it some eight decades later). The Goldman Sachs initial issue sold at a hundred and four and after the crash was worth one and three quarters (Galbraith 1994:70-4).

Galbraith notes that there followed many other examples of closed-end trusts, some even more spacious in scale and imagination. As a result of this explosion of highly leveraged credit, equity prices rose to a peak of 30 times earnings (Beattie 2012). Then, between September 1929 and the end of that October, and without apparent warning, the Dow Jones fell by 40 percent. There followed a further, albeit slower but nonetheless precipitous collapse, so that by July 1932 the Index had fallen 90 percent from its 1929 peak. Speculation had thus again been facilitated by an explosion of unregulated credit. Its level had risen from 45 percent of U.S. GNP in 1925/6 to over 150 percent in 1929 (Elliott 2011). When prices fell speculators were then required to fund a higher percentage of their margins. But the banks would not extend further credit, and debts were liquidated in a self-feeding chain reaction that rapidly extended throughout the global economy. Once again there was public clamor.

Much of this clamor, unsurprisingly, was directed against the banks. During the upturn, many U.S. banks had established security affiliates to float bonds and underwrite corporate stock issues. In this they had benefitted from banking's two classic profit-making strategies: their ability to create credit by increasing their margins of lending as a proportion of their assets, and their ability to use such resources to engage in risky ventures. The banks made massive profits until the crash of 1929. In 1932, after nearly 5,000 banks had failed, an appalled Congress, responding to vigorous public pressure, passed the emergency Glass-Steagall Act as part of Roosevelt's New Deal. The Act imposed controls on bank lending and reintroduced the boundaries that traditionally had governed banks' activities – notably by separating their commercial and investment functions, thereby reducing their ability to take risks.

The Glass-Steagall Act's provisions were made "permanent" in 1945. But the next upturn's lobbying, spearheaded by the financial services sector, again pressed for a loosening of financial controls. Reagan's, and later Clinton's, Congresses responded favorably and the Glass-Steagall Act was emasculated by the Gramm-Leach-Bliley Act of 1999. This imposition of controls during the downturn (when, theorists of plural rationality argue, they are not needed and are actually a brake on recovery) and their later removal, through the lobbying efforts of proponents of the Maximizer strategy, in the subsequent upturn (when, theorists of plural rationality argue, they are essential) can be seen as analogous, but on a "whole system" scale, to those ultimate bad luck firms (we met some of them in chapter 3) that change their strategy as the risk seasons change and always get it wrong. And this sort of "rational maladaptation"[42] is at its most deleterious when there are no dissenting voices: when, at each turning point, just one form of solidarity manages to impose hegemony.

While this sort of "one herd at a time and always the wrong herd" alternation is indeed pretty much what has happened with all four of our cases, it does not have to be like that. Things could be arranged (indeed, as we will see, when we look at insurance companies, are to some extent already arranged) so that, instead of "serial elegance", we have some degree of "continuous clumsiness". Put another way, we can ease ourselves away from the bottom-left province in our Figure 3.6 and up towards the top-right one. Then, as with the tropical rainforest, instead of one massive bout of creative destruction every fifty or so years, we can have much smaller, and much more frequent, patchy collapses: collapses that do not raise that dread specter "too big to fail, jail or bail". We cannot eliminate the cycling – we cannot have "no more boom and bust" – but, as we have suggested in chapters 2 and 3, that cycling does not have to be so all-or-nothing.

B.4 THE 2007/8 CREDIT CRUNCH-CUM-GLOBAL FINANCIAL CRISIS

The Credit Crunch of 2007/8 was triggered by the bursting of a U.S. housing bubble and was distinctive in two ways. First, it was the product of an upturn that had lasted longer than any other and, second, it was fueled by a greater excess of credit.[43] This credit was sourced from the earning surpluses of developing countries – mainly China – and from the recycling of surplus commodity earnings, especially from Australia and Canada. This massively available credit coincided with the Federal Reserve's determination, post the dot.com bust of 2000, to keep U.S. interest rates low, which pressed down global interest rates. As a result, surplus available credit at low prices meant that global returns from investments such as government bonds declined to record low levels. Low returns then encouraged investors to assume more risk by seeking higher returns wherever they could be found. They were found in funding mortgages for the housing market, particularly in the U.S..

Sub-prime mortgages, sold by "bonus-fueled" lenders, led to a U.S. domestic property boom that quickly extended globally, particularly to the U.K.. It was backed by a general supposition that house prices could never decline, and it was further boosted by the increasingly frenetic activity of an orchestrated financial services sector that was extensively backed by cheap credit. In other words, the upward trend – dramatically evident in Figure 2.2 – was expected to continue indefinitely. Of course – again dramatically in Figure 2.2 – it did not.

The U.S. financial services sector was – and still is – dominated by the relatively small number of firms that emerged after a series of amalgamations in the 1990s. In 2006 it comprised five investment banks: Morgan Stanley, Lehman Brothers, Goldman Sachs, Merrill Lynch, Bear Stearns and two conglomerate firms – Citigroup and JPMorgan Chase (which straddled several functions). They were supported by AIG, the world's largest insurance company, and three assessment (or rating) agencies: Moody's, Standard & Poor's and Fitch. Acting in unison, these companies – thanks to a shared and increasingly hegemonic "risk

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[42] "Rational" in that it is the sensible behavior, given their convictions as to how the world is; "maladaptation" in that, unfortunately, the world at that moment is not that way. Hence our choice of the term "rational adaptability", which refers to the situations in which the convictions as to how the world is in alignment with how it actually is (as in the top-left to bottom-right diagonal in our Figure 3.1).

[43] In the U.S. at the peak of the boom in the last decade it had reached 300 percent [a record] while in the U.K., as the boom mounted, people had withdrawn £300 billion in equity from domestic property (Elliott 2011).

culture", along with multiple "revolving doors" to other companies, government/regulatory posts, business school professorships and so on – were integral in exploiting the domestic housing market and ultimately in creating the 2007/8 crash (Ferguson 2011).

On top of all this, a new, sophisticated and highly influential development made its appearance during this upturn; a mathematical formula was devised by which elements of risk could be calculated and factored into transactions, loans could be made and profits gained by lending to people not considered safe by orthodox measurements and then insuring against the odds of their failure to comply (Black & Scholes 1973). The formula was massively applied to value derivatives, enabling them to be traded as commodities prior to maturity. The financial services industry avidly embraced the Black-Scholes formula and

> by 2007 was trading derivatives valued at one quadrillion dollars per year … 10 times the total worth, adjusted for inflation, of all products made by the world's manufacturing industries over the last century. The downside was the invention of ever-more complex financial instruments whose value and risk were increasingly opaque (Ian Stewart, *The Observer* 2012).

The Black-Scholes formula facilitated speculating on speculation. It eventually failed because its mathematics did not take account of certain imponderables which would inevitably intrude, as they did when Lehman Brothers collapsed in 2007. So, this fatally flawed formula provides a further reason for the extended length of the last upturn (and perhaps for the unusually long and disruptive Uncertain phase that has followed on from that Bust). However, the investment banks, seemingly oblivious to these risks, bought up large numbers of mortgages which they then "bundled" into units called "collateralized debt obligations"(CDOs). CDOs thus became the newest member of a family of financial instruments known as "derivatives". Investors were soon snapping them up, thanks to the AAA ratings they were awarded by the rating agencies which, in their turn, were paid by the banks to assess them. Though this may appear somewhat dodgy, the assessors insist that it is not, arguing that if they were to succumb to temptation they would stand to lose credibility, and that such a loss would always outweigh any possible gain.[44]

CDOs, however, were known, by some, to be far from safe investments, since they included 30 percent of subprime mortgages: mortgages granted to those with little hope of sustaining them. They also comprised similarly risky car-financing and student loans. But, because the assessors had rated them AAA, they were eligible to be purchased by retirement funds and other financial institutions, and by individuals seeking safe investments.[45] So, as with the PPI (Payment Protection Insurance) scandal that has now landed British banks with compensation payments totaling £20 billion (with the final figure estimated to reach £35 billion), we have a glaring instance – deliberately engineered or inadvertent – of *information asymmetry*; those who knew the risks were there were able to doom those who did not. Strip away the technicalities and the formulae, and we are back among the divers and dodgers of Tulipmania and the South Sea Bubble!

Did the bankers know that the derivatives they were selling were duff products? "Not all, certainly", is Ben Chu's answer. "There is some evidence", he continues, "that the heads of these banks were as clueless as their customers about the MBSs [Mortgage Backed Securities] and CDOs they were selling" (Chu 2015). In

[44] Loss of credibility *to whom*, however, is the question. The three rating agencies tend to move in something close to lock-step, and they have virtually no competitors. As with the so-called "challenger banks" that, it was hoped, would pop up like mushrooms, entry costs are a major deterrent to the emergence of new rating agencies (as in that old quip "Why is there only one Monopolies and Mergers Commission?").
[45] Retirement funds were prevented, by their legally backed constitutions, from investing in anything other than AAA securities. That this (along with adherence to the tenets of modern portfolio theory) did not ensure that fiduciary duty was duly exercised has now led to a major re-think (see Hawley et al 2014).

other words, the line between skulduggery and incompetence is seldom easily drawn, and we have recently seen the head of Volkswagen in the U.S. testifying that he knew nothing about his company's deliberate cheating over emissions from their cars, and that it was all the work of a couple of software engineers.

There is considerable evidence, however, that the five major U.S. banks *were* well aware of the insecure nature of the housing market and of the CDOs they were selling, for which they took out insurance against the likelihood of a drop in the housing market (e.g. Ferguson 2011; Lewis 2010; Beattie 2012). When the CDOs proved toxic, their purchasers, including many retirement funds, took massive losses, as did the retirees who were dependent on them and AIG (also rated AAA) which was the insurer of last resort. But, as with so many of the banks, AIG was deemed "too big to fail" and required more than $150 billion in taxpayers' emergency aid.

The same rating agencies had similarly assessed Lehman Brothers as AAA, until it too crashed (but was not bailed out) in 2007. Goldman Sachs, however, was unscathed:

In 2006 and 2007, the Goldman Sachs Group, aware of the imminence of a tipping point, peddled more than $40 billion in securities backed by at least 200,000 risky home mortgages, but never told the buyers it was secretly betting [through insurance] that a sharp drop in U.S. housing prices would send the value of those securities plummeting. (Beattie 2012) "Only later", as another commentator observed, "did investors discover that what Goldman Sachs had promoted as AAA-rated investments were closer to junk." McClotchyde (2009)

Parallel deception (i.e. skulduggery not just incompetence) was evident in the U.K. when Sir Fred Goodwin, head of the Royal Bank of Scotland, the U.K.'s largest bank (at one time the world's largest), was publicly denying his bank held sub-prime securities when in fact it was so heavily involved that they brought it down. Deemed "too big to fail", it was bailed out by the U.K. taxpayers, with Goodwin losing both his job and his knighthood in the process.

All this deviant behavior – so different from those days, back in the 1960s, when the City of London's culture could be summarized in the pledge "My word is my bond"[46] – has its roots further back in the upturn. In the 1980s, for instance, Margaret Thatcher's pro-"enterprise culture" government, like that of Ronald Reagan in the U.S., was dedicated to the deregulation of industry and commerce (see Hargreaves Heap and Ross 1992). It was therefore a pushover for the financial sector lobbyists, the result being a large-scale scrapping of regulations: "the Big Bang", as it is called. Its various Building Society Acts allowed building societies to demutualize and become banks: a transition – away, in our terminology, from egalitarian/conservator and towards individualist/maximizer – that also tore them from their local roots and turned them into global (but often none-too-competent) players. Their subsequent buying of sub-prime mortgages then mirrored the U.S. banking experience. Large profits were made, and large salaries and bonuses paid to their executives on the basis of those short-term gains. This continued until (and, indeed, after) most of those newly created banks had crashed (and then been a bailed out) in 2007/8.

As with Tulipmania, the South Sea Bubble and the 1929 Crash, as the upturn moved towards its peak the scale of imaginative innovation grew. Nor were these instances of increasingly audacious deviance restricted to the financial services sector.

[46] For an account of life and culture in those distant and remarkably upright days see Edwards (2008).

In the U.S., for instance, the Enron debacle was massive. Originally trading in electricity, natural gas, water and broadband, and then widely extending its interests, its stock had risen 1700 percent. Described by *Fortune Magazine* as "the most innovative corporation in the U.S.", in its final year it fell from an opening price of $61m to a closing price of 20 cents (Cruver 2003). "At its peak its market capitalization had been $250 billion, the market value of its stock … over $200 billion and its publicly owned bonds $40 billion" (Kindleberger and Aliber 2011:129). It rapidly reached this pinnacle in part by refining versions of the South Sea Company's share-boosting techniques. Enron's senior managers were incentivized by the award of stock options as bonuses so that the bigger and more consistent its profits the more their options were worth. Enron ensured that reported profits were consistently high by over-valuing future contracts and including their revised valuations in current profits, as well as engaging in complex sale and leaseback arrangements. Both methods increased their stated current assets at the expense of future profits. Further, they borrowed in ways that avoided balance sheet notations through legalized accountancy finagling and then used the funds to support their own stock price (Kindleberger and Aliber 2011; Cruver 2003). By these means, the company was able to boost earnings while concealing its debts. But it could do so only for as long as its share price remained buoyant. To this end, and like the South Sea Company, Enron used the press. As well as buoyancy, the consistency of its share price was important to Enron, since the financial press made quarterly assessments of company incomes. A fall in a single month's assessment could lead to a 20 percent drop in the share price. Enron therefore ensured that earnings were "smoothed" with larger than necessary increases in profits being deferred by delaying receipts or prepaying expenses. When profits were less than deemed necessary, they practiced the reverse. Their efforts were eased by payments to certain financial journalists, who received retainers of $25,000 a year for attending one meeting a year.

In upturns there is a general loosening of auditing standards that reflects the overall climate of deregulation, and it was this that facilitated Enron's strategies. After the upturn post 1890s, there had developed a progressive reduction in the expected distance between auditors and those they audited until their interests were perceived as having merged and the profession lost public credibility. In 1913 a new firm, Arthur Andersen, was established. It proclaimed a fresh moral approach and its success in emphasizing conformity to the then downturn's deviance-resisting values was marked.[47] It quickly rose to become one of the U.S.'s top four accountancy firms. It is ironic, therefore, that in the period of deregulation during the past upturn, Arthur Andersen should have become auditors to Enron.

As Enron's auditors, Arthur Andersen merged the incompatible functions of both auditor and highly paid consultant. For these services Enron paid it $2 million and $25 million a year respectively. These dual roles facilitated a whole set of ingenious, accountancy-based scams until the market crashed in 2000 and both firms collapsed together. This was despite consistently positive assessments by Standard and Poor's, who had been paid by Enron to assess it as a suitable vehicle for investment. This it did, awarding it continuous AAA ratings and, along with other rating assessors, maintained this until Enron could no longer juggle its liabilities and imploded. The rating agencies argued that their assessments were largely dependent on the distortions emanating from Arthur Andersen: a bit like VW's boss blaming it all on "a couple of software engineers".

[47] These values extend to wider social concerns: boundaries tighten, and pressures mount to roll back the perceived excesses and tolerances of the prior upturn. Sexual constraints are promoted and women's fashion becomes more modest – no more "flapper dresses" or revealing hotpants – and, along with longer hemlines and covered shoulders, come calls for increased controls over immigration. Conspicuous consumption – so "in yer face" during the upturn – is frowned upon. (For a fuller account of these sort of value shifts see Beckman 1983:333-47.)

While Enron was perhaps the upturn's most dramatic failure, this failure, as Nelken (2007) has noted, represented the "flip side" of the company's earlier success. *Fortune Magazine* had not been wrong; for many years Enron had been a genuinely innovative company. Indeed, in embracing the opportunities offered by the Black-Scholes formula, they had successfully been making money out of risk and thus conforming to the essence of capitalism; they were, in effect, selling insurance. So, Enron's rise and fall nicely illustrates the shadowy nature of the line between parasitism and turning an honest penny: between illegality and being within the law. Sometimes, however, we have actors who are clearly on the deviant, not to say criminal, side of that line.

The ebullient 1990s and 2000s also gave us Bernie Madoff's Ponzi scam: the greatest in history. When the stock exchange crashed in 2008 and his clients attempted to withdraw $11 billion from his fund, they found it was not available. The scale of the fraud was then revealed, with estimates of loss ranging from $20 billion to over $60 billion. Madoff, however, was distinctive only in the scale of his fraud. He was at the forefront of a wide range of lesser Ponzi schemes that flourished through the upturn.

Many forms of upturn deviance involve the manipulation or theft of information which not only includes the spreading of false rumors and the commissioning of journalists "puffing" articles, as in our four cases, but theft of information that facilitates insider dealings. For instance, on 13 April 2011 Raj Rajardnam, founder of the Galleon Hedge Fund, was convicted in New York of insider dealings. The judge estimated his takings were "well over $50 million", derived from corporate acquisitions and by benefiting from inside knowledge of large changes to corporate earnings (*New York Times*, 27 April 2011). Rajardnam was later jailed for 11 years and fined $10 million. He worked through a network of executive informants in major companies and was arraigned with 26 others, accused of passing or applying confidential information.

As the current downturn proceeds, another aspect of managerial behavior is increasingly seen as deviant (though not criminal) which was not considered so during the upturn. Senior U.K. managers (mirroring similar changes in the U.S.) increased their pay from a multiple of 14.5 of average worker's pay in 1979, to a multiple of 75 in 2009-11. This discrepancy is widest at the very top. In 2011 the average CEO of a FTSE 100 company was taking home 145 times the basic pay of an average worker, *plus* bonuses, pension payments and share options – averaging, in all, £4,365,636 against average earnings of £25,900 (High Pay Commission, 2011). These differences have continued to accelerate. Top managers in 2009-10 increased their takings by a further 30 percent, and in 2010-11 by 49 percent, compared to their workers' average increases of 2.3 percent and 2.5 percent (*The Guardian*). These later increases were awarded after the downturn was well established and when some businesses – and especially banks – were not even covering the cost of their capital in terms of the risks taken.

This – our final example – raises an intriguing question: how is it that managers, in many cases irrespective of their company's performance and in marked contrast to what has obtained in the past, have been able to increase their share of their company's profits so massively? The answer, it has been suggested (by Lord Myners, the U.K.'s Financial Services Secretary from October 2008 to May 2010),[48] is that it has resulted from a progressive uncoupling of the balancing elements in corporate governance. In the conventional wisdom, the different forms of power exerted by managers, "independent" directors and shareholders (the owners) are expected to balance out, and in a way that ensures that the business is run for the long-term benefit of the shareholders, thereby reining-in inherent managerial excess: a clumsy compromise in our terminology, that prevents a slide into elegance – into a situation where the individualist/maximizer voice

[48] In a radio program, "In Business – Corporate Governance", presented by Peter Day, BBC Radio 4, 14 August 2011.

drowns out all dissent. This balancing act, it is argued, has now failed as shareholders have progressively conceded their power to the managers, withdrawing their traditional oversight as long as those managers produce favorable, albeit short term, results: an accelerating process that Warren Buffett (2001) sees as being operated by "Ratchet, Ratchet, Ratchet and Partners".[49]

B.5 SIMILARITIES IN VARIATION

Our four selected cases show that, though history may not repeat itself, it most certainly rhymes. In each period there are evident variations in institutional structures, in dominant technologies and in the sophistication of deviant and fraudulent practices. But the dynamics of each upturn remain similar: they reveal the same patterns of bubbles, followed by the same patterns of crashes. While methods of manipulative innovation become progressively more complex, they too remain essentially the same. And each sequence, "fits" the amended regularities of Kondratieff's economic cycles.

We find that, as markets rise, deviant insiders have attempted to boost their company's prospects by lying in public pronouncements, by planting false rumors and by secretly selling out at what they believe is the top of the market while continuing to encourage sales to the wider public. These were the practices during Tulipmania in 1636 and of the South Sea Company's directors in 1720. And they emerged again prior to the 1929 Crash and yet again in The Housing Crash and Credit Crunch of 2007/8.

In the more obvious examples of deviance, we therefore see variations of practice but consistency in the principles employed. The extensive operations of "riggers" in Tulipmania are paralleled by the escalation of contemporary "boiler shops", whose principals trade with each other to increase the price of stocks they hold – the resulting rises in price encouraging repetitive "cold-caller" sales to gullible investors. Other consistent variations involve borrowing on overstated assets to buy lavish life-styles – as the directors of the South Sea Company did in 1720 and the directors of Parmalat did before it crashed in 2010.[50] And after each crash, public perceptions of what is and is not deviance shift and pressures mount for government regulation against entrepreneurial (in our terminology, individualist/maximizer) excess. *Déja vu* all over again, in other words.

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[49] In terms of our "easy to use boardroom device" (Figure 3.6) this process takes the "policy sub-system" all the way from the sunny heights of "clumsy institution" to the dismal depths of "closed hegemony".

[50] The dairy food manufacturer, the eighth largest firm in Italy, failed to meet interest liabilities of €18 billion.

Appendix C: More Details of Property Casualty Transition Matrix Development

Table C.1

DISTRIBUTION OF RBC RATIOS

Percentile	RBC Ratio (%)
1.0%	312
5.0%	447
10.0%	539
25.0%	702
33.3%	**770**
50.0%	901
66.7%	**1070**
75.0%	1173
90.0%	1485
95.0%	1738
99.0%	2666
max	3674

Table C.2

DISTRIBUTION OF COMMON STOCKS AS PERCENT OF SURPLUS

Percentile	Common Stocks as Percent of Surplus
1.0%	1.2%
5.0%	7.1%
10.0%	11.4%
25.0%	19.0%
33.3%	22.0%
50.0%	29.1%
66.7%	36.6%
75.0%	41.9%
90.0%	61.1%
95.0%	75.0%
99.0%	100.7%
max	133.8%

Table C.3

PREVALENCE OF ASSIGNMENTS OF APPROACH TO THREE INDICATORS OF RISK

Assignments	Count (Company/Year)
111	73
112	59
113	58
121	69
122	81
123	68
131	79
132	61
133	54
211	49
212	42
213	72
221	57
222	63
223	61
231	80
232	101
233	74
311	87
312	60
313	100
321	65
322	64
323	71
331	41
332	69
333	42

Assignments are in the order of Premium, RBC, Common Stock; where 1 is Low Risk, 2 is Medium Risk and 3 is High Risk.

Table C.4

ASSIGNMENTS TO OVERALL BELIEFS

Assignments	Count (Company/Year)	Overall Belief
111	73	Conservator
112	59	Conservator
113	58	Conservator
121	69	Conservator
122	81	Manager
123	68	Pragmatist
131	79	Conservator
132	61	Pragmatist
133	54	Maximizer
211	49	Conservator
212	42	Manager
213	72	Pragmatist
221	57	Manager
222	63	Manager
223	61	Manager
231	80	Pragmatist
232	101	Manager
233	74	Maximizer
311	87	Conservator
312	60	Pragmatist
313	100	Maximizer
321	65	Pragmatist
322	64	Manager
323	71	Maximizer
331	41	Maximizer
332	69	Maximizer
333	42	Maximizer

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