EDITORIAL
MODELLING THE FUTURE: ERGODICITY
AND THE SCIENCE OF THE ACTUARY

The heart of actuarial science lies in its models. Whether our models are deterministic or stochastic, they constitute the basis for actuarial advice and decision-making. Most of our models are derived from experience. Some of them, such as those affected by future interest rates, are calibrated to information related to current expectations as reflected in the market. But what happens when we have evidence that, in some fundamental sense, the future will not be like the past?

A time series is said to be ‘ergodic’ for a particular parameter if unbiased estimates of the sample parameter, based on historical samples, will converge in probability, over time, to the corresponding parameter for the time series. (Hamilton, 1994) In essence, none of our sample parameters will be unbiased estimates of the future unless the future behaves like the past. This does not apply only to time series. It applies to all statistical models. All our models are based on the assumption of ergodicity.

Figure 1 illustrates an ergodic process with a well-behaved expanding funnel of doubt. Figure 2 illustrates a non-ergodic one.

The problem with the non-ergodic time series is that, with probability 1, it will never return to what it was before. After a mutation in a few years’ time it evolves into an entirely new animal.

In the greater scheme of things, the history of a particular variable, it may be argued, is a sample of one observed vector. It happens to have one component per year, but it is only one observation. If the future is going to be fundamentally different from the past then looking out of the back window will condemn us to live in yesterday’s world.

In this editorial I discuss the failure of global capitalism; the discourse I am suggesting is not that global capitalism will fail, but that it has failed—in particular that it has failed to distribute wealth and to maintain stability and environmental, social and economic sustainability. In exploring these failures I attempt to find ways of correcting them. Finally I extract from these ramblings some implications for the future of actuarial modelling.
The failure of global capitalism
The main functions of an economic system are:
– to produce wealth;
– to distribute the wealth it produces; and
– to maintain stability and sustainability both in its production and in its distribution.
The world’s economy is currently dominated by global capitalism, an economic system characterised by the power of multinational corporations, the focus of those corporations on the maximisation of profits, and the reduction of government to a marginal role in the economy. In the past, global capitalism has not failed to produce wealth. The primary failure of global capitalism has been its failure to distribute wealth. Its secondary failure has been its failure to maintain stability and sustainability. In due course, this secondary failure will come home to roost: the production of wealth will suffer from the environmental, social and economic unsustainability of global capitalism.

In order to ensure environmental, social and economic sustainability, corporate entities need to measure, manage and be held accountable not only for their financial bottom lines, but for their triple bottom line—i.e. for the effects of their activities on the environment, on society and on the economy.

In the following sections I discuss the failure of global capitalism to distribute wealth, and its failure to maintain environmental, social and economic sustainability and to maintain economic stability.

The failure of global capitalism to distribute wealth
The GINI coefficient, which measures income inequality, is a useful indicator of inequality in the distribution of wealth. South Africa and its neighbours are the worst in the world, with coefficients close to 70%. The USA and China are both better than 50%, but if one were to put them together they would be much worse. This is because, whilst the USA has a high GDP per capita, China’s is much lower. In fact the World GINI coefficient is now even greater than South Africa’s. The world is more unequal than any of its countries. The reason is that most of the inequality is between countries, not within them. In a sense, therefore, South Africa is both a microcosm of the world and a potential laboratory for the world. If any system is going to work globally it must work in South Africa.

The disturbing thing here is that the world GINI coefficient is getting worse and worse. Figure 3 shows the history of the world GINI coefficient. Whilst it shows signs of levelling off, this is largely because of a natural upper limit. Income inequality is far worse today than it was in the early 1800s.

At the root of the failure of global capitalism to distribute wealth lies the fact that it requires more consumers earning living wages than it requires workers earning living wages. To the extent that capital is more efficient than labour, global capitalism will invest in capital rather than hiring workers. But the problem is that consumers of the products of global capitalism need work at living wages in order to buy those products. Competition between labour and capital thus results in the exploitation of labour, widespread unemployment, poverty and increasing inequality.

Not only does global capitalism disadvantage labour relative to capital, it also disadvantages consumers through the quest for monopoly rents and through the abuse of information asymmetries. Information asymmetries arise in the sale of a product about which the seller knows more than the buyer, or vice versa. This includes moral hazard and adverse selection. As actuaries we are aware of adverse selection against the producer
of a service such as life assurance. But the more typical and more problematic situation is that in which the seller knows more than the buyer. One example relates to value for money—for example in professional fees—where the consumer is unaware of the time and expertise required for a particular service or of the quality of the service provided. Another example relates to planned obsolescence in everything from pot scourers and toothbrushes to toasters and fridges. The abuse of information asymmetries by corporate entities results in the over-pricing of goods and services and in consequent transfer of wealth from consumers to corporate producers and retailers.

**Environmental sustainability**

With regard to the sustainability of the effects of economic activity on the Earth’s biosphere, the first issue is that, amongst politicians, economists and managers, the environment is generally seen as a subset of the economy. The environment does, of course, have an important effect on the economy, but that is not the whole story. The planet can sustain an ecology without an economy. It cannot sustain an economy without an ecology. The economy is a subset of the environment. This means that resource constraints are not only constraints on the economy but also on the environment for its own sake.

The most serious instance of the failure of global capitalism to maintain environmental sustainability lies in its failure to deal with the tragedy of the commons. The tragedy of the commons is the depletion of a shared resource by individuals, acting independently and rationally according to each one’s self-interest, despite their understanding that depleting the common resource is contrary to their long-term best interests. It refers, for example, to overgrazing and overfishing, and to the unsustainable exploitation of natural resources and negative externalities like greenhouse-gas emission and pollution.

![Figure 3. World GINI coefficient](image-url)
In order to deal with the tragedy of the commons we need to hold corporate entities accountable for the effects of their activities on the environment. And in order to hold them accountable for those effects, we need to measure the state of the environment, and we need to measure the effects of individual entities’ activities on the state of the environment from time to time. The latter measure may be referred to as the ‘environmental bottom line’. In fact, though, the reference to a ‘bottom line’ is misleading; what we need to measure is something more akin to value added.

What, then, do we measure for this purpose? What we need are measures of ultimate effects on the environment in terms of which entities can be held accountable as producers, brand-owners and investors.

The first issue here is the multidimensionality of the state of the biosphere. One can measure it in terms of carbon footprint—in tons of CO₂ per person per annum. One can measure it in terms of ecological footprint—in hectares of productive land per person. One can measure it in terms of biomass, biodiversity, soil quality and biological energy, in terms of biosphere pollution on land, in water and in the atmosphere, or in terms of the depletion of environmental resources.

Various measures are already in place, but they are measures of corporate practice, not of the ultimate effects of corporate activities on the state of the environment. The ISO standards fall into this category. These standards tend to encourage a tick-box approach to environmental practices.

Producers of environmental, social and governance (ESG) indices use measured criteria to assess the environmental practices of corporate entities. For example, the MSCI Global Environment Index measures company practice with regard to alternative energy, sustainable water, green building, pollution prevention and clean technology. But again the focus is on environmental practice, not environmental effects. A similar problem arises with the performance indicators of the Global Reporting Initiative. ESG mutual funds—unit trusts that focus on ESG features—also measure environmental practice.

Just as good financial management practice does not necessarily ensure good financial results, so good environmental management practice does not necessarily ensure good environmental results. We need to achieve accountability for the environmental effects of a company’s activities. Our objective here is not ESG filtering for investment, it is for environmental mainstreaming and for the measurement of the entity’s own triple bottom line. That includes, but is not limited to, its investments in other firms.

Not only do we need to measure the effects of an entity’s activities on the state of the environment during a particular reporting period, we also need to measure the long-term environmental sustainability of corporate activities. Sustainability must be measured by means of models of ultimate effects at future time horizons.

Environmental ‘capital’ is a useful concept, but it may be reductionist; whilst it takes the environment seriously as a contributor to the economy, it fails to take the environment seriously for its own sake. By reducing the environment to its dollar value to the economy—either in terms of the cost of replacing an ecology or in terms of the economic costs of destroying it—we are saying that the environment is nothing but its dollar value.
Not only is it difficult to measure the environment itself, it is even more difficult to measure a corporate entity’s effects on the environment. How do we work out which entity caused particular damage to the environment? And how do we know what the state of the environment would have been but for a particular firm’s activities?

These are difficult questions, and they are not model-free. The answers we get will depend on the assumptions we make. But we need to start addressing them. The ultimate environmental costs of corporate production need to be understood and measured, and corporate producers need to be held accountable for them.

Because of our experience in modelling, there may be a role for actuaries here, but we shall have to learn from the experience of environmental scientists involved in the modelling of the biosphere.

**Social sustainability**

Polanyi (2001) describes the relationship between society and the economic system as follows:

> Ultimately…the control of the economic system by the market is of overwhelming consequence to the whole organization of society; it means no less than the running of society as an adjunct to the market. Instead of an economy being embedded in social relations, social relations are embedded in the economic system.

What he is arguing is that, just as we need to turn the system on its head as between the environment and the economy, so we need to turn it on its head as between society and the economy.

The relationships between an entity and society may be analysed in terms of stakeholder relations, namely labour, consumers, suppliers, local communities, investors and the general public.

The first sphere we consider is labour. The irony of the relationship between labour and capital is that, whilst capital improves the efficiency of labour, it competes with labour as a factor of production. Under global capitalism, whilst capital and trade are liberated, labour is immobilised. Whilst capital and goods can move around the world with ease, labour, except as migrant workers with curtailed rights, is largely confined to its own country. We have created apartheid along our borders. Not only does this disadvantage and alienate the citizens of the two-thirds world from the industrialised world, it also blinds the citizens of the industrialised world from the effects of the system that they are imposing on the world for their own advantage.

Global capitalism does not need full employment for its labour requirements. So excess production is largely consumed by the wealthy or invested into more capital, particularly in capital-intensive industry. The trickle-down to the poor is at best only a secondary effect. Labour faces outsourcing, exploitation and alienation. The result is the destruction of ‘social capital’.

Like ‘environmental capital’, the concept of ‘social capital’ is a two-edged sword. It purports to measure the social networks, the social cohesion, the level of trust and the norms and values in a society. But like environmental capital, it may be reductionist. The
elements of social capital are important in and of themselves, not just as contributors to the economy. As noted above, what we need is labour-intensive investment. This will reduce unemployment, improve the distribution of wealth and enhance the formation of social capital.

The irony of the relationship between the consumer and the seller of the consumer goods and services is that the seller must treat the consumer as king, generally regards the consumer as target, and may have to deal with the consumer as activist. The outcome of this complex relationship is consumerism—a social and economic order that encourages the purchase of goods and services in ever-greater amounts. It includes the commodification of social goods and services, which undermines social capital. It enhances the conforming consumer against the creative community.

Then there are the suppliers. Suppliers—especially small suppliers—are increasingly being dominated by the big retailers. This results in the disempowerment of small producers, and again the destruction of social capital.

Local communities suffer from emissions and noise. They also suffer from lack of consultation. And most importantly, they are excluded from the local provision of goods and services that fosters social capital.

Investors are also disempowered by the structure of their relationship with producers. These relationships typically work through a hierarchy of financial institutions, which serve to alienate members of retirement funds, life-assurance policyholders, investors in unit trusts and depositors in banks from the economic investments being made on their behalf. Even where trade unions are active amongst retirement-fund trustees, they often fail to engage in shareholder activism on behalf of their members. Whilst socially responsible investment is gaining ground, it is largely ineffectual in mainstreaming environmental and social concerns. The culture of the financial-services industry is shackled to its title: it is about finance, not about the environment or about society.

And finally, of course, there is the general public. Society gives corporate producers considerable privileges. On the one hand, it allows them limited liability, a concession not available to individuals. On the other hand, when it comes to legal persona, intellectual property and general property rights, they are treated like individuals. Society deserves benefits from these privileges. Of course it does benefit; it receives goods and services. But, as for the ultimate environmental costs, the ultimate social costs of corporate production need to be understood and measured, and corporate producers need to be held accountable for them.

In classical economics, producers were economic agents just like individuals. Profits were a reward for risk. Under global capitalism, risk persists, but in large corporate entities the quantification and management of risk are increasingly controlling it. In today’s multinational corporations, profits are a reward for corporate power, monopoly rent, information asymmetries and the externalisation of costs through the exploitation of the environment and of vulnerable people.

Like environmental capital, social capital is difficult to measure, but some measures have been proposed and implemented. The Gallup World Poll measures experienced well-being. The United Nations measures the human development index. Numerous
local once-off measurements have been reported in the sociology literature. As in the case of environmental capital, the measurement of the effects of a particular corporate entity’s activities is even more difficult.

Corporate social responsibility largely comprises add-on projects for public-relations spin. It is not generally mainstreamed into corporate activity. As for environmental indices, index producers like MSCI have produced measurement-based social-performance indices and as for environmental indices they tend to focus on practice rather than outcomes.

As for the environmental, we need a social bottom line (or social value added). For this purpose we need measures of the state of society, and measures of the effects of a corporate entity’s activities on the state of society from time to time. The measurement of these effects includes measurements of the effects of the entity’s activities on poverty, morbidity and mortality, general well-being, levels of trust and participation in social networks. These effects need to be measured for each stakeholder group and added over all stakeholder groups.

Again there may be a role for actuaries here, but we shall have to learn from the experience of sociologists, demographers and epidemiologists.

**Economic sustainability**

With regard to economic sustainability the main issue is the end to the phenomena that have driven economic growth in the past, such as cheap oil and the information revolution.

Mineral resources such as oil are often included as environmental resources. For the sake of clarity I have limited the measurement of the environmental bottom line to effects on the Earth’s biosphere.

The world’s oil-based economy is now coming to an end. Both before and since the oil inflation of the 1970s and -80s, we had relatively cheap oil with which to grow our economies. Now, however, as we face the end of our payable oil reserves, things are beginning to change. Reserves are now about 64 years’ consumption.\(^1\) Whilst reserve growth is still being reported by OPEC countries, some of this growth appears to be dubious.\(^2\) Most of the reserves are now unconventional.\(^3\) These are generally much more expensive to exploit.

As Bloomberg says:\(^4\)

> For most of the last century, cheap oil powered global economic growth. But in the last decade, the price of oil has quadrupled, and that shift will permanently shackle the growth potential of the world’s economies.

---

1. OPEC Share of World Oil Reserves 2010. OPEC, 2011
In the long run, oil will effectively be eliminated from the world’s economy. But in the mean time, peak oil, when production reaches its peak, will result in even greater increases in oil prices than we have seen in recent years. The most optimistic estimates of peak oil predict that it will occur in 2020.

The lesson we must learn is that we can expect no further growth from oil, let alone cheap oil. On the contrary, peak oil will result in substantial downward pressure on future returns on capital employed. Though the time scales differ, similar effects will emerge for other energy resources such as coal, natural gas and uranium.

Now let us look at the future of the information age. I am not prophesying the end of the information age. What I am prophesying is the end of the revolution that started it.

According to the latest forecast by Gartner Worldwide, IT spending is projected to total US$3.7 trillion in 2013. But that is only the tip of the iceberg. Seventy to eighty per cent of developed economies’ gross domestic product (GDP) is in the services sector, which is increasingly computer-driven. Computer technology is now disappearing into more specific devices, so it is not predominantly computers and associated hardware and software and it does not appear in Gartner’s forecasts.

Because of the recoupment of development costs and intense competition in the industry, the cost of IT continues to decrease, so its contribution to the GDPs of industrialised countries will decrease. Long-term economic growth from IT is going to depend on future innovation.

In developing countries there is much more potential for IT-led growth. The roll-out of mobile phones in Nigeria is an example. But there it is hampered by decades of colonial and neo-colonial exploitation, inadequate infrastructure and lower levels of education.

The start of the information age was a unique development. It will never happen again. The information age will continue and another dot-com bubble is unlikely, but once it has stabilised, and in the absence of unexpected future innovation, IT will no longer contribute to substantial economic growth.

There may be other industries like the energy and IT industries in which we cannot expect the future to be like the past. We cannot assume that past sources of growth will persist into the future.

It is forty years since *The Limits to Growth* was published by the Club of Rome (Meadows et al., 1972). In that book the authors asked:

Is it better to try to live within that limit by accepting a self-imposed restriction on growth? Or is it preferable to go on growing until some other natural limit arises, in the hope that at that time another technological leap will allow growth to continue still longer? For the last several hundred years human society has followed the second course so consistently and successfully that the first choice has been all but forgotten.

Depending on the assumptions made, they predicted either economic and societal collapse or a stabilised world by the late 21st century.

---

5 Gartner Says Worldwide IT Spending on Pace to Reach $3.7 Trillion in 2013, www.gartner.com 2/7/2013
In 2008 Graham Turner at the Australian CSIRO produced a follow-up (Turner, unpublished). He found that changes in industrial production, food production and pollution are all remarkably in line with the book’s predictions of economic and societal collapse in the 21st century.

So now we are increasingly hearing appeals for a reversal of the growth trends of the last few centuries. As Sweezy (1989) puts it:

Since there is no way to increase the capacity of the environment to bear the [economic and population] burdens placed on it, it follows that the adjustment must come entirely from the other side of the equation. And since the disequilibrium has already reached dangerous proportions, it also follows that what is essential for success is a reversal, not merely a slowing down, of the underlying trends of the last few centuries.

Amongst these calls is a new movement calling for ‘degrowth’. The Second International Conference on Degrowth, declared:

In the midst of an international crisis more than four hundred researchers, practitioners and civil society members from forty countries gathered in Barcelona in March 2010…. The Declaration of the First International Conference in Paris in 2008 noted the looming multidimensional crisis, which was not just financial, but also economic, social, cultural, energetic, political and ecological. The crisis is a result of the failure of an economic model based on growth…

But capitalism as we know it is dependent on growth. Industries that are dependent on new investment in economic capital—and therefore on economic growth—are critical to industrialised economies. In the absence of growth those industries experience particularly serious reductions in returns on capital. The effect spreads to other industries, resulting in severe decline. Whilst short periods of decline are a normal feature of capitalist economies, no growth would result in the collapse of the global economy. (Douthwaite, 2000)

Particularly problematic is debt-fuelled growth. The banks encourage such growth by granting credit for unproductive purposes, and by obliging individuals to provide for their own long-term financial needs instead of relying at least partly on the provision by future workers of social security and social support. This necessitates investment in commercial and industrial companies on profitable terms. This is good, provided the investment is in labour-intensive industry, especially when it comes to foreign investment. What happens, though, is that those who pay the piper call the tune. Companies must produce financial growth in order to satisfy the demands of investors. Actuarial advice is part of this process. We try to help financial institutions to optimise their portfolio allocations with reference to their liabilities. Unless we take cognisance of the environmental, social and economic bottom lines, our asset–liability models may be part of the problem, not part of the solution.

How do we change the economic system to one that is economically sustainable?

In the first place, just as we need to measure the environmental and social bottom lines of corporate entities, we also need to measure their economic bottom lines. The
financial bottom line of a corporate entity does not represent the economic results of its activities; reference should be made instead to the economic bottom line, after allowance for externalised costs and spurious economic activity—i.e. economic activity that does not add to the wealth, or the well-being, of the world. Externalised costs and income from spurious economic activity should be deducted from value added to determine the true economic value added by the entity.

But more radically, we need a conversion from global capitalism as we know it to capitalism as if people and the environment mattered. Properly mainstreamed environmental and social responsibility will ask whether the pursuit of the financial bottom line detracts from that of the social and environmental bottom lines. Capitalism will be only part of the solution, and it will have to be a substantially diminished part.

In order to make capitalism work, the multinational corporations will have to be reined in. We shall need limitations to the treatment of corporate entities as legal persona, particularly with regard to intellectual property, but also with regard to limits on their rights relative to human rights and the rights of small entities.

We shall need labour mobility. People will need to be freer to move from country to country.

We shall need labour-intensive investment. Capital will have to be seen as a means of empowering workers, not as a threat to them.

And then, as Schumacher (1973) tells us, small is beautiful. We need to encourage small and medium enterprises. We need to foster local economies. The movie The Economics of Happiness gives an idea of the importance of such economies. It tends to err on the romantic, but nevertheless, it makes a good point.

Part of the small-is-beautiful movement is the cooperatives movement. It already constitutes a substantial sector of the economy. A particular manifestation of the cooperative is the mutual assistance scheme. In South Africa there are reportedly over 6 million people who belong to burial societies.

The creative-community movement supports people in creative activities. Eco-villages promote environmentally sustainable self-supporting communities.

All these alternatives need to be fostered and supported.

Not only do we need capitalism as if people mattered and the fostering of the small and the beautiful, government’s role also needs to be rethought.

First we need new thinking on economic policy. Government needs to see the economy as a subset of the environment and society. We need to mainstream the ‘new economics’ movement, which offers new thinking in fields such as banking and finance, local economies, macroeconomics and social returns on investments. There are refreshing new winds blowing through socialism, taking it beyond the ideological straitjacket of the past. There are attempts to find a synthesis in the dialectic between Keynesian and classical economics.

Government needs to nationalise monopolies, companies that are too big to fail, companies producing dangerous products and natural resources. It needs to regulate, tax or fine ecologically and socially unsustainable practices.

Government’s primary role, of course, is the protection of the vulnerable. But we
need to focus this role on human security and social security, not on state security and the security of the elite. The main security needs of the poor relate to basic necessities and essential services. Second-generation rights need to be upheld. This includes rights to education, work, social security, food and an adequate standard of living. Vulnerable local economies need to be protected.

In addition to the implementation of economic policy and the protection of the vulnerable, the third role of government is the provision of infrastructure including utilities, public transport and roads and railways. This needs to be done by government for the people. Government needs to avoid outsourcing and concessions.

Just as private companies must focus on the triple bottom line, so should government, both in its budgeting and in its reporting. Also, some of the problems of global capitalism are equally relevant to government. For example, the relationship between government and its workers needs to be constructively managed. Worker alienation and the principal–agent problem are arguably even more fraught in the public sector than in the private sector.

**Economic stability**

Not only does an economy need to be sustainable, it also needs to be stable.

Klein (2007) argues that, in order to spread world-wide, global capitalism depends on socio-political disasters. Harvey (2010) argues that periodic episodes of meltdown are not only inevitable in the capitalist system but essential to its survival.

An instance of the failure of global capitalism to maintain stability is its vulnerability to systemic risk, particularly the contagion caused by inter-linkages, interdependencies and the cascade effects between them. We have discovered this to our cost in recent years. This is exacerbated by the emergence of corporate entities that are too big to fail.

Part of the problem of global capitalism lies in the complex web of interdependence in global finance. Support for stable local economies and self-sufficient enterprise will serve to limit the effect of global interdependence on the stability of the system.

**Implications for actuarial modelling**

The above analysis suggests that the models of future returns on investments are essentially non-ergodic. We need to consider the implications of that analysis for the actuarial modelling of returns on investments. Assuming in our models that the future will be like the past, and that the distribution of future returns on investments will be like that of past returns, is like taking credit now for the profits on products not yet even developed. The message from the past is that we cannot expect similar financial growth in the future. In order to survive, the economy will have to evolve into something different from the past. The economic bottom line will be lower, future dividends will be lower and returns on investments will be lower.

This is a message we have heard before. Wilkie (1995) made the point in a paper that neatly explains the equity risk-premium puzzle and warns us that we cannot expect the same returns from shares in the future as we have received in the past.

The Institute and Faculty of Actuaries of the UK recently commissioned a study...
on the implications for the actuarial profession of resource constraints (Jones et al., unpublished). That study explores the economics of the limits to growth and the current discourse on that subject, as well as the current evidence for constraints on various resources of economic importance. It develops four possible scenarios for the future and it discusses the implications of those scenarios for actuarial science.

The four scenarios are defined with reference to the sensitivity of markets and of government, as depicted in Figure 4. In that figure, each quadrant defines a scenario. ‘Business as usual’ is the worst scenario, describing the case in which “governments and markets have low sensitivity to resource limitations.” The best scenario is ‘consensus-driven change’, in which “governments operate on a long-term basis and regulate the stock of resources, rather than the flows.” ‘Regulation-driven change’ and ‘price-driven change’ are intermediate scenarios; the former describes the case in which governments are sensitive and the markets are not, and the latter the converse.

For each scenario, the study creates a narrative illustrating what the authors suggest the outcome would be in terms of economic growth and in terms of social cohesion and security. These narratives are then quantified in terms of key variables of interest to actuaries. Table 1 shows future long-term annual investment returns under the scenarios described above.

The returns shown in Table 1 are considerably lower than the expected returns typically used in actuarial modelling. Furthermore, the study suggests that the variability of financial returns will be greater in the future than in the past. In the past, by using historical data in actuarial modelling, we have implicitly assumed business as usual in the future. We have also implicitly assumed ergodicity. Table 1 suggests, however, that business as usual is a particularly pessimistic assumption. Its implications for future
returns on investments will be particularly pronounced and historical data will be of limited use.

Table 1. Long-term annual investment returns under the scenarios described

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Long-term real investment return p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pessimistic</td>
</tr>
<tr>
<td>Business as usual</td>
<td>0%</td>
</tr>
<tr>
<td>Regulation-driven change</td>
<td>0%</td>
</tr>
<tr>
<td>Price-driven change</td>
<td>1%</td>
</tr>
<tr>
<td>Consensus-driven change</td>
<td>2%</td>
</tr>
</tbody>
</table>

The link between the narratives and the quantification is highly subjective. Whilst it serves as an illustration of how the future might differ from the past, it cannot yet form the basis of actuarial modelling in any mechanistic way. Nevertheless, the profession will need to embrace the subjective. Where actuaries need to make subjective assessments of appropriate assumptions, the study could inform the process. It could also inform a dialogue between an actuary and her/his client with regard to the likelihood of the various scenarios and the implications with regard to the assumptions to be made. Such a dialogue would also enable the client to own the model. The suggested scenarios and the associated key variables could also help in the assessment of prior probability distributions for Bayesian modelling.

The study is a challenge to actuaries to start modelling the triple bottom line, not only so that we can start developing an understanding of how resource constraints will affect our clients’ financial bottom lines, but also so that we can start quantifying our clients’ own triple bottom lines. The triple bottom line involves a much wider range of variables than the financial bottom line, with a much more complex web of interrelationships. We are going to need to find ways of simplifying that complexity, with inevitable compromises between parsimony and realism.

The study makes no reference to the failure of global capitalism. That was outside of the commission given to the authors. More research needs to be done on this subject. We shall need to explore the implications for our clients and their stakeholders of the alternatives to global capitalism. If it is assumed that the alternatives to global capitalism will result in reductions both in the efficiency of production and in distributions of the value-added that will reduce shareholders’ profits relative to the benefits of other stakeholders, the effects on future returns on the market portfolio will be even worse than those suggested in Table 1.

Conclusion

By recognising the interdependence of the environment, society and the economy, by recognising the non-ergodic, evolutionary nature of economic systems, by recognising the problems of the past, by exploring solutions for the future, and by pursuing the implications of these things for the future of actuarial modelling, we shall be enhancing both the discipline and the profession of the actuary.
Acknowledgements
I acknowledge my debt to Mrs Taryn Reddy for conversations about the measurement and modelling of the triple bottom line and for helpful comments on a previous version of this editorial. I also acknowledge help I received from Dr Philip Machanick regarding the economic effects of information technology.

RJ Thomson

REFERENCES