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Giving Preparedness a Central Role in Science and Innovation Policy

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Abstract

Over the last few decades public policy and public management methods have been very much concerned with the *management of risk*. Risk by definition is quantifiable, or if not quantifiable, something that can be 'managed'. In contrast, the preparedness perspective places far more emphasis on the need to deal with *uncertainty* – challenges that cannot be easily quantified, accurately forecasted or managed. Although the distinction between risk and uncertainty is not clear-cut (and is often the troubled area where policy-makers find themselves working), a strong bias towards framing the challenge as 'manageable' risk can, in practice, be distinguished from the more important challenge of handling substantive uncertainty. The preparedness perspective stresses the key role of governments in managing the economic, social, environmental and national security consequences of this substantive uncertainty. Preparedness also clarifies why government funding for basic research is so important: basic research, in essence, translates ignorance into risk. We explore the unknown because we want to find out more about it – human beings prefer to face risks than uncertainties because we can (attempt at least) to act rationally in response to measurable risks. Consequently, giving preparedness a central role in science policy would counter-balance and address shortcomings in current science and innovation policy frameworks. Such a shift in emphasis would also make it easier to defend spending on capacity building in public science. In an uncertain world, the ability to respond quickly and effectively to the unforeseen is critical. Indeed, preparedness capacity is critical to setting the innovation objectives that allow us to respond to unforeseen threats. The paper recommends five complementary principles for giving preparedness a more central role in science and innovation policy.

(1) Being more realistic and honest about limitations to forecasts and predictions, particularly in complex systems environments where simple Newtonian dynamics of linear cause and effect do not apply.

(2) Making a more explicit distinction between risk and uncertainty, and doing more to understand the 'fuzzy' grey area between the two, again giving due recognition to the inherent unpredictability of complex systems.

(3) Putting more effort into demonstrating how science translates uncertainty into risk and in so doing increases our levels of preparedness.

(4) Adopting 'preparedness friendly' guidelines for research funding and performance evaluation that utilise 'risk-facilitating' portfolio-based investment methods.

(5) Doing more to specify how preparedness outcomes are reflected (in the short term) in greater accuracy in the estimated Net Present Value of economic assets and also (in the very long term) the challenge of being fairer to future generations.

Keywords: complexity; uncertainty; risk; preparedness; science; innovation; policy.

Science and preparedness

Science in its broadest sense, particularly basic research and public science, is our principal resource for helping us to grapple with the uncertainties and risks over what the future has in store for us. By attempting to understand how things work in an objective manner, as free as possible from ideology and bias (though these problems are always present and active), science alerts us to what *may* happen and what the consequences *might* be. Sometimes, science gives us early warnings well before future risks become empirically apparent – a major advantage of good theory.

The critically important role played by science in helping us to deal with the uncertainties and risks we may face in the future is, however, complicated by a tendency to under-state the limits to our understanding of the future in public policy in general. The statement "is the Treasury modeling right or wrong", as one politician put it in a debate over Australian Treasury projections, is revealing in what it tells us of the underlying assumptions about uncertainty and risk. When the scope of mathematical models extends into the future and complex systems such as economy are involved simple notions of veracity and falsification become problematic. What happens in the future is inherently hard to predict – so we do our best with the information and technical tools at our disposal – but our best is inevitably limited. In such circumstances, whether something is 'right' or 'wrong' can only be judged after the case, not before the case. Whilst forecasts (whether they be economic, social, environmental or in the national security domains) attempt to make the best of complex and difficult issues, they inevitably confront areas of fundamental uncertainty – which limits measurability.

Science also provides us with sophisticated tools for identifying, measuring and understanding complex phenomenon. Indeed, most areas of natural science involve a substantial investment in technical improvements to these tools. These tools are the technical means of translating uncertainty into risk. For example, a new imaging technology developed via basic research will characteristically allow previously unseen features and processes to be viewed and analysed. Such imaging tools allow us to move from substantive uncertainty over what is happening to the risk that we have incorrectly hypothesised what is happening. These principles apply to astronomy, physics and medicine, together with numerous other disciplines and subject areas. Technological innovation in imaging, analysis and modeling tools is the primary driver of progress in translating uncertainty into risk. We invest in the R&D to develop and improve these technologies because we have an aversion to ignorance and uncertainty and would in many cases prefer to know more about the risks that we face in order to be better prepared and to decide how to react.

This contribution of science is such a fundamental part of our lives that we tend to overlook the enormous value derived from reduced uncertainty over what the future may have in store for us.

In our search for tangible "outcomes" from science, the "yield" on tax-payers investments in innovation and the commercialisation of research, we often fail to give adequate weight to, and measure, the economic and social value of being forewarned and acting accordingly.

However, anyone familiar with public policy will be all too well aware of the ways in which policy definition and implementation tends to be an exploratory/experimental and therefore a *learning* process. Unintended consequences, positive and negative, are not unusual and are almost inevitable in such circumstances. These learning processes tend to operate in the grey area between uncertainty (immeasurable risk) and quantifiable risk.

The grey area between risk and uncertainty

If we think about both public policy and markets in this more open ended way - as exploratory processes *and* selection mechanisms – then it is easier to understand their limitations and, hence, grasp why preparedness and innovation are so important in helping us to manage uncertainty. Markets can, within boundaries, cope with risk (quantifiable likelihoods and estimated consequences) but they cannot cope as easily with substantive ignorance and uncertainty.

In this context, economists often draw a useful pragmatic distinction between risk and 'Knightian' uncertainty: immeasurable risks and sheer ignorance about what may happen, see Knight (1921). Frank Knight's perspective on these matters was influenced by the 'Austrian' tradition of subjectivist economics. This stream of thinking is distinguished from neo-classical economics in some fundamental ways, which are highly relevant to understanding both preparedness and innovation. Rather than a world of quantitative uncertainty as defined within the empirical paradigm in risk and uncertainty analysis (quantifiable problems that yield a 'neutral' 50:50 balance of probabilities) the Austrian economic perspective describes a human condition in which creativity is a necessary response to qualitative uncertainty (effectively ignorance) over what the future has in store – both good and bad.[2] In some circumstances there are no probabilities to assign to future states of the world, but rather the necessity to act *creatively* in order to generate parameters that can be assigned probabilities (and hence managed 'rationally'). The resulting competition is *inherently* a process of discovery and innovation. From this standpoint, markets are inherently *exploratory* and *innovative* collective endeavours that operate via selection and in which pattern recognition plays an important role, see Kirzner (1973, 1979), and Hayek (1967).

The public sector faces the acute challenge of dealing with immeasurable risks, ignorance and uncertainties - managing the domains in which markets are ineffective as resource allocation mechanisms. Consequently, the government officials faced with these challenges stress the

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[2] A useful discussion of different perspectives on ignorance and uncertainty can be found in Smithson (1998) and Smithson (2008).

importance of the 'grey' area between measurable risks and ignorance/immeasurable risks. In practice, governments must deal with risks that are hard or impossible to quantify and quantified risks with large margins of error that attract little trust and credibility. Structured decision-making processes and discussions can help in addressing such challenges (hence the emphasis within the public sector on committee structures, inquiries, reviews and evaluations).

It is significant that the practitioners who engage in these structured processes sometimes express a wish that better formal methods were available and sometimes anticipate that the march of progress will eventually deliver technical solutions. This is a particular feature of funding programme reviews and evaluations. Again, this tends to reflect a lack of recognition of the problem of ignorance and substantive uncertainty. Many issues, including the 'return on investment', are inherently unknowable for complex situations (other than over the very long term) *but* this does not mean that government interventions are neither useful in general nor critically important in some instances.

All public sector programmes focus on attempting to change the future in ways that are preferred over others, but this does not mean that a mechanistic validation of additionality is possible outside of some special cases: the systems are often far too complex and subject to second-guessing and complex feedback loops. Indeed, the more important the challenge, the more complex and intractable the problem, and the greater the likelihood of severe negative unintended consequences – the so-called 'wicked problems' challenge, see Australian Public Service Commission (2007).

Looking for useful outcomes from public science (and innovation) in translating immeasurable uncertainty into measurable risk, and how these outcomes help us to cope with the grey area between uncertainty and risk, helps us to articulate a more realistic conception of the 'return on investment' from public science. In so doing, this helps us to re-balance program evaluation methods by avoiding reliance on the 'smoking gun' audit trail of tangible unitary outputs and outcomes (patents, spin-offs, license income etc).

In contrast, over the last two decades or so a particularly strong emphasis has been placed upon the 'smoking gun' ethos: research commercialisation as *the* expected outcome from public R&D. The assumed simplicity - and measurability - of this type of outcome has undoubtedly contributed to the rise of this perspective. Patents, licenses, start-up companies and the like can all be measured as outputs. These tangible features tend to assist policy-makers in budget negotiations and help to reassure the general community that "value for money" is being sought in a (reasonably) transparent manner. More recently, the policy narrative has started to focus on impediments to collaboration – framed as an end in itself rather than as a means to an end. Collaboration may be becoming the new commercialization.

Arguably, there is a “Panglossian” tone to this perspective – rapid scientific and technological progress generates bountiful commercial opportunities – all we have to do is to reap these rewards if we are to live in the best of all possible worlds. We therefore search for the impediments to commercialisation and (more recently) collaboration on the assumption that there must be such impediments because both the level and timeliness of commercialisation and collaboration does not match our expectations given the levels of spending on R&D.

The result is that science policy has tended to be subsumed under innovation policy – leading to a defensive posture associated with attempts to frame many inherently worthwhile benefits from public science as innovation related outcomes (narrowly conceived in research commercialisation terms). It has proved difficult for the science community to articulate a compelling case for government support for science that moves beyond the “research for its own sake” ethos that has become increasingly unfavourably regarded in advanced OECD economies.

The FASTS response: preparedness

In reaction to the over-emphasis on traceable commercial outcomes from public science and an under emphasis on the uncertainty to risk pathway and its benefits, in 2006 the *Federation of Australian Scientific and Technological Societies* (FASTS) commissioned a paper that set out to increase the prominence of an important aspect of capacity-building in science and innovation – our ‘preparedness’ for anticipating and responding to undesirable and damaging future events, see Matthews (2006).

Previously, the term preparedness was used mainly in relation to defence, counter-terrorism and natural hazards. The wider use of this term is deliberate, and attempts to focus policy thinking on the far more extensive aspects of how science helps us to deal with uncertainty and risk. Of course, science and innovation are also partly responsible for many of these unfavourable future scenarios (from endocrine disrupters in our water supply through to weapons of mass destruction). Indeed, the need for preparedness is generated in part by the unexpected consequences of science-based innovation - the unwelcome downside of modernity. Many areas of innovative activity address these unwelcome consequences of scientific and technological progress. We should not forget that the problem of climate disruption due to athropogenic CO_2 emissions is largely a consequence of investments in industrial R&D of various types (e.g. in power station technologies, motor vehicles and aircraft) taking place since the industrial revolution. Whilst technological innovation is now a contributing solution to this major problem it is also a major, if unintended, cause of the problem.

In seeking to establish ‘preparedness’ as a more explicit outcome class in science and innovation policy, the 2006 paper highlighted the enormous economic, social, environmental and political benefits that are generated by ‘prescience’: being better informed (by public science) about what the future might have in store for us if we carry on acting as we are. The widespread dissemination of this information alters people's, and corporations', expectations about the future. This in turn, can lead to changes in current behavour that change the likelihood of these undesirable future outcomes emerging. This line of argument was subsequently reinforced by the publication of the Stern Report in the UK, which empirically articulated this type of case in relation to the costs of delayed actions (and hence of *not* being forewarned and able to respond), Stern (2007).

The underlying principle of the case for treating preparedness as an outcome class is similar to the calculation of Net Present Value (NPV) in economics and finance. The understanding gleaned from public science alters the *current* value of economic assets because it alters the expectations about the future that determine what these current asset values are. This dimension provides a 'downside' mitigation argument that complements existing arguments over the social value of government support for science and innovation – a policy narrative that traditionally stresses the potential 'upside' gains to be reaped from exploiting intellectual property rights, company start-ups and spin-offs etc.

One very important aspect of the preparedness outcome class is that it opens up an avenue for being clearer about the ways in which public science addresses inter-generational equity concerns (i.e. fairness to future generations). Greater awareness of future uncertainties and risks helps to counter-act myopia in decision-making. By being better informed about what the future may have in store for us, and how we can therefore change the future by changing what we do today, public science helps to decrease what economists call the social rate of discount. This is the rate at which we collectively discount the value of things that may happen in the future. The lower the social rate of discount the higher the value we are willing to place of the future consequences of our current actions. If we have little information on how our current behaviours may affect future generations then it is understandable that we will tend to heavily discount the future. Public science helps us to value future states of the world more highly with consequent impacts on current behaviour and investment decisions.

Indeed, the social rate of discount is a key factor in the financial discount rates used to calculate the Net Present Value of assets. The greater the discount rate the lower the Net Present Value of an asset. Of course, Net Present Value estimates will be over-stated if future uncertainties and risks are under-stated. This can lead to a situation in which there are nasty surprises – unfolding events lead to dramatic and unexpected drops in asset values. As the global financial crisis illustrates, these drops can be very de-stabilising – socially, economically and politically.

From this angle, the preparedness outcome class helps to draw attention to the importance of seeking to avoid significant and unexpected drops in asset values by being better informed about future uncertainties and risks. Consequently, the preparedness outcomes generated by public science generate the long-term benefit of enhanced fairness to future generations *and* the present term benefit of a reduced risk of unexpected and destabilising drops in the current value of economic assets.

From a public policy perspective, these two benefits can reinforce each other in useful ways. Reducing the social rate of discount helps governments to address their key role in worrying about inter-generational equity issues (something markets cannot do as well). This longer-term perspective, in turn, reduces the risk that the current values of assets are over-stated in the face of risks and uncertainties – making markets more efficient as a means of allocating resources. In short, the enhanced levels of preparedness arising from public science make markets more efficient in the present whilst also helping to counteract the short-termism that tends to be inherent in market behaviour.

The Australian Government's response

FASTS used the 2006 paper articulating the case for preparedness as an outcome class as the basis of its submission to the Productivity Commission's *Review of Public Support for Science and Innovation*. These arguments gained traction with the Productivity Commission (PC) and, as a result, the PC's report stressed the importance of these types of benefit, whilst also noting how difficult such benefits are to measure. Following the Productivity Commission's work, the notion that preparedness should be made explicit as an outcome class was supported by the standing committee of the *Prime Minister's Science, Engineering and Innovation Council* (PMSEIC) and also featured in new guidance on measuring research outcomes issued by the inter-departmental *Coordination Committee on Science and Technology* (CCST).

The case for adopting preparedness as a generic outcome class pertinent to innovation in the public sector as a whole was subsequently also articulated in Matthews (2009). Adopting preparedness, and the key distinction between uncertainty management and risk management that this entails, could lead to more general transformations in how output-outcome budgeting is implemented at the programme level. In particular, it is necessary to adopt definitions of legitimate and desirable outcomes that emphasise reductions in uncertainty as being intrinsically valuable.

It is noteworthy that the 2008 *Review of the National Innovation System* chose not to endorse the emphasis placed on preparedness in the earlier Productivity Commission report. The reasons for this are unclear, but it may have been because the case for preparedness was viewed by those advocating more support for innovation as a competing rather than as a complementary concept. If this is the case, then it is still important to explain and demonstrate how support for preparedness reinforces support for innovation – and particularly industrial innovation. Demonstrating how innovation enhances our levels of preparedness for dealing with the uncertainties and risks identified via public science simply reinforces the importance of possessing effective national and international innovative capacity. It does not detract from the importance of 'broad brushed' innovation capacity, as framed by the recent Cutler Review.

If we are to pursue a more balanced approach in science policy, in which commercialisation and preparedness outcomes *both* receive the attention they deserve, then we need to articulate how preparedness can be measured – and its value estimated. Some techniques for this do exist as this is how investment banks seek to make their money (so-called "value-at-risk" methods). Consequently, there may be much to be gained from far stronger engagement between the science policy community and the financial sector (and especially insurance companies). One advantage of preparedness-based approaches is that they avoid the "more jam tomorrow" problem: we obtain the benefits now because this is the point at which we judge the present value of future risks and associated costs – in exactly the same way that financial analysts calculate the present value of a future stream of investment yields. Preparedness-based thinking opens up a rich new seam to mine as regards outcome measurement.

With luck, it won't take us too long to achieve the better balance we are looking for - casting a more sceptical eye on Dr Pangloss. We need to get better at assessing how widely (and freely) disseminated research findings influence behaviours – behaviours that help to make the future world(s) we may live in less unpleasant than might otherwise be the case.

Moving forward

Five basic principles for moving forward in counter-balancing the research commercialization approach to innovation with the preparedness dimensions of science suggest themselves.

Firstly, policymakers need to work harder to create more receptive conditions for implementing preparedness by being more realistic (and honest) about the limitations to forecasts and other predictions. There is diminished scope for recognizing the importance of preparedness as an outcome class from public science if we pretend that governments, business and the general community do not face substantive uncertainty over what the future has in store for us. The more realistic and therefore honest we are about the limitations of our understanding of the future, the greater the value that we will place on investments that improve our understanding. In democracies, this means that widespread public debate over preparedness related issues is inherently useful because it requires us all to be more realistic about what governments can and cannot do in the face of substantive uncertainties that can affect us all. Greater honesty over the limitations to policy interventions encourages more effective debates over policy matters – debates in which substantive uncertainties are recognized and 'blame' for failures, and credit for successes, makes more explicit recognition of contingent and unexpected events and processes.

Secondly, both policymakers and the general community need to make a far more explicit distinction between uncertainty and risk. The existence of immeasurable risks, and concerns, and in some cases sheer ignorance, over what may happen (a feature of pandemic preparedness), means that it is often inappropriate to allocate blame for policy and service delivery failures. Whilst blame is worth allocating when relevant information was ignored, we all need to recognize that there are cases in which, without the benefit of hindsight, predicting what may happen was inherently *unknowable* at that time. The events concerned happen under conditions of uncertainty rather than measurable risk. Whilst measurable risk, including financial risk, can be treated as a commodity – and offset, traded and allocated - uncertainty born of ignorance about what may happen is a shared problem that requires a collective response.

Thirdly, given the importance of being more honest about the limits of our understanding of the future, and therefore of recognizing the distinction between uncertainty and risk, those responsible for science policy should be far more active in stressing how science translates uncertainty into risk, and in so doing, elevates our levels of social, economic and environmental preparedness. From this perspective, the objectives of innovation (as it is conventionally approached) are often set by the preparedness outcomes created by public science. Preparedness (the ends) and innovation (the means) have a complementary relationship to each other.

Fourthly, it would be helpful to articulate new 'preparedness friendly' guidelines for research funding allocations and performance evaluation. The adoption of more risk and uncertainty-aware investment portfolio methods would assist in this regard. It would be preferable to bundle together discrete research projects addressing similar challenges into Preparedness Research Portfolios. Preparedness Research Portfolios would be funded and evaluated at the portfolio level – allowing for greater risk taking in the sense of exploratory and truly experimental work at the individual project level. The selection of these bundles of projects, which would require that appropriate levels of quality in research design and track record are achieved, would explicitly mix low and higher risk projects ('sure bets' with left field projects). Project selection would also pay attention to offsetting risks and uncertainties between projects in order to strengthen the portfolio as a whole. In evaluating Preparedness Research Portfolios what matters is how the overall portfolio has performed. 'Failures' of some projects to achieve stated objectives can and should be tolerated as an inevitable consequence of this type of uncertainty and risk aware approach to funding and evaluating research. The outcome of increasing levels of preparedness (better awareness of, and options for dealing with, potential threats, hazards and other downside factors) would of course be an explicit attribute in selecting and evaluating this type of scientific research. This latter attribute would rectify a major shortcoming in current approaches – the penalisation of failures to 'follow through' on potentially useful advances in knowledge. Given the value that business places on the public science system developing preparedness options for possible use should certain future circumstances emerge, the adoption of the Preparedness Research Portfolios system is likely to receive widespread support from the business community.

Finally, given the ways in which preparedness outcomes are reflected in asset valuations (in the present) and inter-generational equity concerns (over the very long-term) there is useful technical work still to be done on incorporating these outcomes into mainstream research evaluation methods. Capturing the value of preparedness outcomes in this manner will hinge upon estimating how a better understanding of uncertainties and risks faced in the future affects asset values, and also on calculating the impact of any changes in the social rate of discount on these asset values. In each case, counter-factual assumptions based on the 'denial cost' of *not* possessing given preparedness outcomes are required, and will be reflected in asset values that may be under-stated or over-stated depending upon complex circumstances. Success in these technical efforts can be defined as the availability of credible counter-factual estimates that capture the difference between asset valuations with and without the outcomes from given Preparedness Research Portfolios. The larger the difference in asset valuations, and consequently the lower the severity of possible market corrections that might take place in the future, the greater the value of the preparedness outcomes that have been achieved.

If we develop science and innovation policy in this manner then we will articulate a more balanced approach than exists at present. We don't need to rely on technochratic solutions in order to implement preparedness as a policy framework – only greater *realism* and *honesty* over the challenges faced by public policy in general. We over-emphasise innovation outcomes and under-emphasise preparedness outcomes (rather than the complementary relationship between the two) because we misrepresent the fundamental challenge faced in governance. This is that we inhabit a world beset by substantive uncertainty over what the future has in store for us.

Paradoxically, it may be the case that the major emphasis placed on innovation as an outcome from spending on science has contributed to the conditions for introducing preparedness as a central feature in science policy. The adoption by governments of innovation-based narratives applied to what happens in the public sector brings with it the necessary recognition of the fundamental role of uncertainty management in governance. Hence, the increased emphasis on learning by exploration and experimentation within governance. Given this, we should do more to learn from post-Newtonian physics – whose intellectual authority stems from rejecting simple and unambiguous mechanical models and embracing and managing the existence of uncertainty, ambiguity, complexity, reflexivity between the observer and the observed - and to understand the consequent limits to prediction that stem from these conditions.

Preparedness matters as an outcome class in science and innovation policy because it opens up a pathway to 'post-Newtonian' public administration in general – a paradigm in which risk is not always something to be eliminated (like friction) and in which uncertainty may arise as an emergent property of the system itself (especially if it is complex).

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