

Chapter 1

FTA as Due Diligence for an Era of Accelerated Interdiction by an Algorithm-Big Data Duo

Denis Loveridge and Cristiano Cagnin

Abstract In the face of the ‘digital revolution’ and its wide penetration of all aspects of life, FTA needs to consider new approaches and skills to enable it to cope with a ‘new’ world. An approach based on ‘due diligence,’ adapted from the business world, is suggested. The paper links the digital world to an algorithm-big data duo, where computation is preferred to human judgment, with its behavioural and intuitive ‘baggage’, in policy formulation. Turing’s 1936 paper enabled the evolution of digital computers capable of using complex algorithms to work with large and uncertain data sets. The current favouring of computation highlights the need for FTA to be based on an appreciation of dynamic situations that face all life on Earth replacing silo-based problem-solving. To cope with these situations, new skills are needed based on excellence in breadth and depth using due diligence concepts that can build a bridge between FTA and policy makers to ensure both the quality and the ability to embrace ignorance are coped with.

Keywords Algorithms • Big data • Ignorance • Existence • Extinction • Emergence • FTA skills

1.1 Introduction

In its infancy TA was the embodiment of a protest movement before it became institutionalized in the US Office of Technology Assessment and the UK’s Programmes Analysis Unit, both of which are now defunct. Huddle (1972) defined TA initially. By 1996, the situation had changed and a revised definition empha-

D. Loveridge (✉)

MIoIR, MBS, University of Manchester, Oxford Road, Manchester M13 9PL, UK
e-mail: denis.loveridge@manchester.ac.uk

C. Cagnin

Center for Strategic Studies and Management (CGEE), SCS Qd 9, Lote C, Torre C, 4º andar,
Salas 401 A 405, Ed. Parque Cidade Corporate, Brasília, DF 70308-200, Brazil
e-mail: ccagnin@cgee.org.br

© Springer International Publishing Switzerland 2016

T.U. Daim et al. (eds.), *Anticipating Future Innovation Pathways Through Large Data Analysis*, Innovation, Technology, and Knowledge Management,
DOI 10.1007/978-3-319-39056-7_1

sized uncertainty (Dale and Loveridge 1996). Since 1996, the characteristics of FTA do not seem to have changed much. The fascination with methods seems unending but Wittgenstein's dictum that 'methods pass the problem [situation] by' calls for human judgement to be promoted. In the evolving digital world, engagement with what will later be called 'the algorithm-big data' duo enters in increasing force. The paper explores how this duo has grown in importance. The argument develops through Sect. 1.2, where some primary notions of FTA are set out; Sect. 1.3 describes the relation between FTA, living systems and complexity; Sect. 1.4 highlights some notions about ignorance; Sect. 1.5 describes the relation between human decision-making and computation; Sect. 1.6 illustrates the algorithmic world; Sect. 1.7 does the same for the big data world; Sect. 1.8 explains the duo of algorithms and big data; Sect. 1.9 proposes a different approach to FTA aligned with some new skills; these are described in Sect. 1.10. The paper ends with a brief discussion (Sect. 1.11) and conclusion (Sect. 1.12).

FTAs' conventional concern was the linkage between new technologies and social development which was perceived during the enlightenment well before the notion of 'economics' was born as a cultural invention. In the digital world, advances in communication technologies have quickened the pace of science and technology and has created globalization of world markets. However, a long, slow running unease with the assumption that all S&T were 'good things' and that human mental plasticity would always adapt to them began to split society. Rejection of these assumptions grew from 1970 onwards and has been accompanied by the rejection of technological determinism, through exposure of its hidden social consequences. Soddy (1922) provided a scientific criticism of the conventional economic mantra. However, it was probably the use of nuclear weapons to end World War II and tensions during the Cold War that gave added impetus to the questioning of the role of S&T in human development. The conceptual and methodological basis of FTA was developed in this period and first systematic methods (e.g. Delphi) were developed at that time.

A clamour grew simultaneously for the governance of S&T. New fora for involving the public in the governance of S&T came in many forms: these highlighted the breadth of the situations involved as a cascade of them evolved over the last 40 years. 'Unpredictable' events increased recognition that global systems are uncertain and complex, causing the notions of 'grand challenges' and sustainability to emerge. All of the above occurred during a persistent rearrangement of the world's chessboard of power that has now (2014) moved towards the Pacific Basin in which invention and innovation, and their risks, are an important part of the emerging landscape. Now there is much force to Whitehead's perception that 'Science is concerned with generalities. The generalities apply, but they do not determine the course of history apart from some anchorage in fact'. FTA affects *all* life and has a pivotal role to play in assuring the continuation of basic services and infrastructures, human rights, freedom, democracy and privacy, all of which is threatened through risk, regulation and governance. All the above points to the necessity for new skills for FTA practice towards one which encompasses ignorance, complexity and creativity.

1.2 Primary Notions of FTA

Cagnin et al. (2012) described the role FTA plays' in informing decision-making, structuring and mobilizing actor networks and capacity-building among innovation actors. FTA is part of foresight which, for the sake of clarity here, will be assumed to endeavour to identify future possibilities from what is known or can be speculated about from current knowledge; this involves *subjective opinion*. The kernel of subjective opinion is the ability for people to project their substantive knowledge into the future to assess and represent uncertainties concerning the future, in a non-empty way. Non-emptiness implies speculation or opinion, based on an incomplete understanding of events (ignorance) since the future is by definition *unknown*.

Briefly, Dalkey (1969) describes the nature of the knowledge experts have at their disposal: the gradations from knowledge to opinion and from opinion (or speculation) to conjecture are hazardous as opinion or speculation implies the presence of *incomplete* evidence: reasoned opinion or speculation can then only be made on a probabilistic or fuzzy reasoning basis, though the expert will usually decline to attach any kind of measure to his opinion. The further their reasoning goes into the future, the further their opinions move towards the fuzzy transition into conjecture, where evidence to support their opinions becomes fragmentary. Amara and Lipinski (1983) demonstrated that most experts are far too confident, when extending their knowledge into the future (so what of non-experts?), frequently leading to 'lock-in' even though what is sought are patterns from all the streams of their experience that *seem relevant to the situation*.

In most studies opinions, expert or non-expert tend to be regarded as of equal weight; this is not a valid assumption. However, this vexed behavioural question has never been resolved though there is fragmentary empirical evidence that some expert opinions are many times more effective than others (Amara and Lipinski *ibid.*). Experts and non-experts have to consider two very broad sets of entities and their intersections, neither of which can be clearly identified (Fig. 1.1).

The fuzziness of foresight (and FTA) is evident from Fig. 1.1, so that notions of certainty are misplaced. Rather, it is as well to acknowledge the phenomenon of *ignorance* (discussed in Sect. 1.4). Lastly, the important issue is understanding how ideas do emerge, in a random manner and sometimes fleetingly, through the fuzzy boundary between the unknown and the barely appreciated.

1.3 Living Systems and Complexity

The situations that FTA addresses are living systems that evolve, regenerate and self-organize themselves to adapt to changing circumstances. Maturana and Varela (1980) described these as autopoietic complex adaptive systems where change is self-organized creating an emergent structure and pattern without external

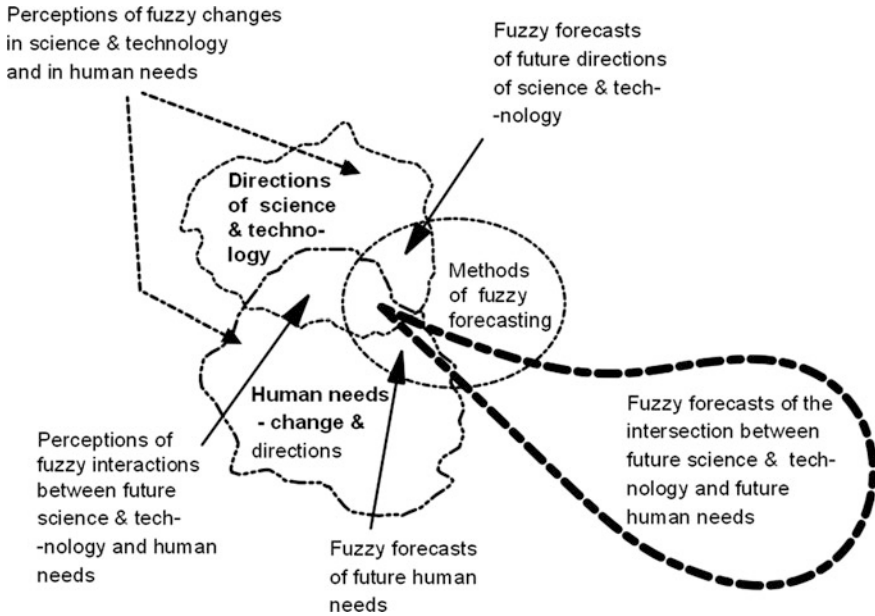


Fig. 1.1 Intersection of human needs, science and technology and methods of forecasting

intervention. Every organism has the ability to self-generate implying continuous auto-production and reproduction (Maturana and Varela 1997): autopoietic systems are a product of themselves (Rocha 2003), have self-defined boundaries and are organizationally closed. Living systems learn and use new information to alter present and future behaviour to maintain internal homeostasis.

Complex adaptive systems are unpredictable: their emergent behaviour is more than the sum of the properties of parts and this relationship is ill-understood.

Dempster (1998) described as sympoietic, a complex ecosystem which does not have self-defined borders and that are collectively produced as well as organizationally ajar. Dempster (2000) concluded that autopoietic systems are homeostatic, development oriented, centrally controlled, predictable and efficient, whereas sympoietic systems are homeorhetic, evolutionary, distributively controlled, unpredictable and adaptive. Hence, one of the most important differences between autopoietic and sympoietic systems relates to the balance between their ability to maintain their identity despite changes in the environment and to adapt their identity to fit changes.

For FTA, the above descriptions present a useful heuristic to complex living systems that share matter, information and energy with their external environments: there is simultaneous autonomy and interdependence with a requirement for interactivity Rocha (2003). These matters are relevant to the understanding of social systems and their internal connectivity.

The information, knowledge and ignorance that are shared within social systems can lead to individual and collective adaptation and evolution. What one part does to another is indefinitely interpreted and informed to form more complex chains. The system will then be able to make legitimate evolutionary leaps characterized by the appearance of emerging properties. In this context, mutual trust (Maturana 1998; Losada 1999, 2001; Fredrickson and Losada 2005) is crucial for choosing a common path for life or for moving the whole system towards higher levels of sustainability. Dialogue and information sharing, founded on trust (forms of ‘handshaking’), are prerequisites for both.

Existence imposes real limits that are controlled practically through extinction events. The combination of existence and extinction has the nature of a feedback loop that produces forms of stability: these only get out of control when that balance fails producing an inequality in the form of ‘persistent’ feed-forward, which can be either positive or negative, until stability returns but in a different way, a phenomenon called homeorrhexis. Ultimately, an inequality between existence and extinction leads to major crises for living systems. Each crisis stems from the summation of a myriad of individual events. In current parlance, these crises are called ‘grand challenges’ though history is littered with such traumas for life on Earth, humanity in particular, that have been referred to under different names.

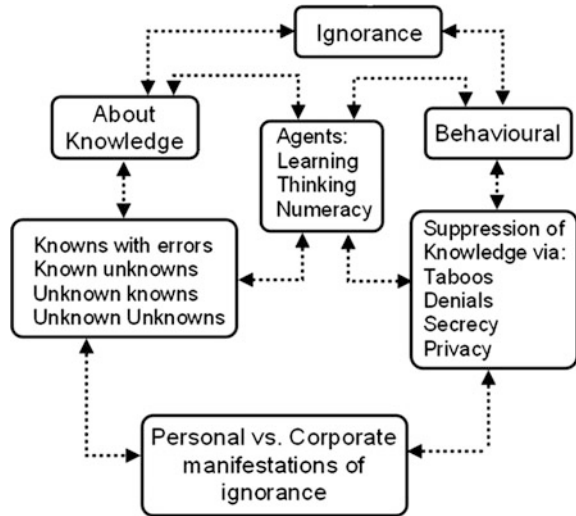
In this context, social change implies that people within a society must change: this happens either through encounters outside the specific social system or via reflections through language (Maturana and Varela 1997), requiring handshaking between policy makers and FTA practitioners, as well as between social actors in general. Basic emotions are the basis of the operationalization of living organisms, and these change as the environment changes, requiring an individual to adapt to his/her environment to avoid disintegration.

FTA becomes key to enable a creative dialogue and the interactions required to allow social systems to behave as sympoietic complex systems (Cagnin and Loveridge 2012). Features of universal ethics or universal principles and those of respect (Zohar 1990) can be linked with notions of high-performance teams and organizations (Losada 1999, 2001).

1.4 Notions of Ignorance

Appreciation of complex and dynamic situations lies at the heart of FTA in which the future is logically redundant because if a science, technology or engineering is known or imaginable it is no longer in the future, and only their applications lie there together with their ethical, legal and social influences (ELSI). Due diligence embraces ELSI studies that necessarily encounter various aspects of ignorance: in this frame, *ignorance is not the antithesis of knowledge*. Ignorance penetrates ELSI very deeply both technically and behaviourally. In engineering and invention, ignorance is a well-appreciated matter: it lies at the root of the dilemma of a system being ‘fail-safe’ (a long-established engineering and risk principle) rather than the

Fig. 1.2 Summary of Roberts taxonomy of ignorance



ecological principle of a system being ‘safe when it fails’ (Holling 1977). Roberts (2012) sets out a taxonomy of ignorance, summarized in Fig. 1.2, that indicates the duality of ignorance being ‘about knowledge’ and ‘about the behavioural influences’.

In engineering, ignorance breeds an appreciation of the need for caution in design procedures (fail-safe principle) which, through SEEP and V pressures, over recent decades has become formalized through the ‘precautionary principle’. Stirling (2008) introduced important matters concerning science, precaution and politics relating to technological risk in particular. Stirling’s key factors were uncertainty (characterized by probability), ambiguity (presumably of information) and ignorance: these can be fitted into Robert’s taxonomy beneficially.

For policy, the clash between ignorance and knowledge, and its many grey areas, creates serious dilemmas for policy makers that can be illustrated as in Fig. 1.3. Policy makers tend to resolve these situations by imposing agreed boundaries on them to enable the appreciation of risk; boundaries to these perceptions and their fitness for purpose, valuation and risk. How these ‘boundaries’ are conceived and drawn then becomes an important matter. If the boundary regards the situation as autopoietic rather than sympoietic, then the outcome will be markedly different. An autopoietic situation can be regarded as organizationally closed, effectively becoming a silo, whereas a sympoietic situation will be characteristically ajar and open to outside influences, perhaps acknowledging the nature of the ‘real’ world devoid of silo features. These notions generate conflicts in the realities of policy making creating a sense of appreciation of ‘existence’.

For policy makers, it is essential that FTA creates of a sense of ‘handshaking’ (Boettinger 1969) and common ground for appreciation of the situation within the taxonomy of ignorance (Fig. 1.2). These steps begin to create a common language for appreciation. In the real world, ignorance can become mired in behavioural traits

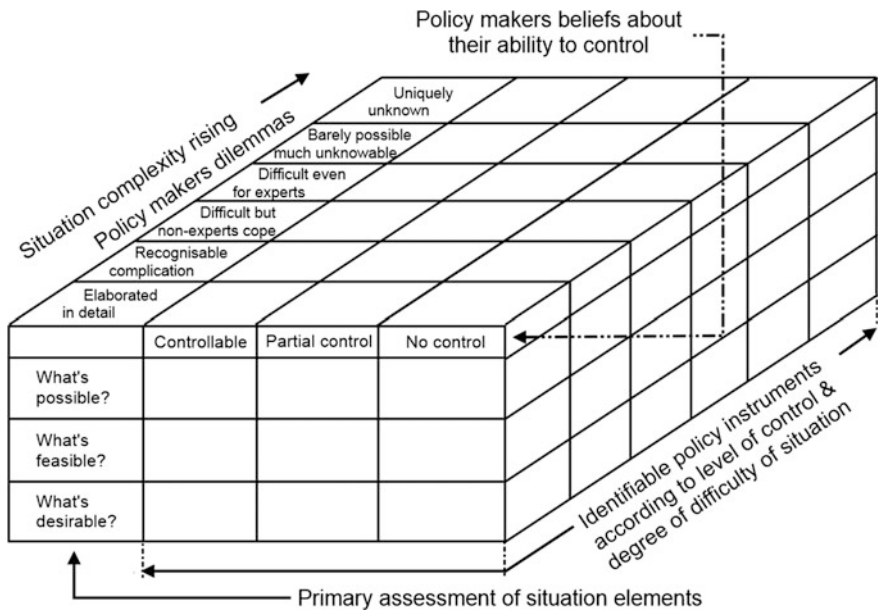


Fig. 1.3 Policy-makers dilemmas (© Denis Loveridge reproduced with the kind permission of Routledge)

that make themselves apparent in corporate ignorance characterized in the way shown (Fig. 1.2). However, it is the merging of the two streams of ignorance that poses hazards for policy makers and corporate executives. For example, when ‘known unknowns’ are suppressed in order to ensure that policy outcomes are achieved, this amounts to limiting the policy makers dilemma to ‘recognizable complication’ that is ‘controllable’ to achieve ‘what is desirable’ (Figs. 1.2 and 1.3). Behaviourally, this implies the adoption of a highly constrained appreciation of the dynamic situation and the absence of a common language for policy and leads to a biased and partial model.

1.5 Human Decision-Making Versus Computation

In many ways, polities have been lured into accepting a preference for numbers in place of thought without necessarily appreciating either how the numbers were produced or what they mean. Computation and the computational models that create them have grown an aura of their own creating a conflict between important decisions made through human processes rather than those that rely on computer-based models. These conflicts have been characterized journalistically as ‘Computers and you or computers or you’ (Loveridge 1983) a view expressed

similarly by Michael (1962) and more trenchantly by Eric Schmidt chairman of Google (Schmidt 2014) and are referred to again in Sect. 1.9.

Belief in numbers is convenient being seen as a way to remove or at least limit the effects of ignorance. Funtocwiz and Ravetz (1990) devised the NUSAP system for understanding numbers in policy making including their more exotic role of how, why and who created them. Whitehead's notion of the fallacy of misplaced concreteness similarly reveals why overemphasis on numbers, however produced, is unwise (Whitehead 1925) creating conflict from differing beliefs without settling the questions posed through ignorance and different personal 'models' of a situation.

FTA models of situations are bounded and may be qualitative, quantitative or a mixture of both. Qualitative models are unavoidable as they are the precursors to any form of later quantitative model. Qualitative models set out a linguistic appreciation and description of a situation of concern: they need to be investigative (later called 'due diligence'), imaginative and based on the evolution of common ground as referred to earlier. Inevitably, common ground needs to cope with the influences of ignorance rather than to focus exclusively on what is believed to be known. Because of their real-world complexity, models of situations are bounded thus limiting appreciation of their wider world influences, imposing strong demands on how these boundaries are created and the 'handshaking' required in doing so.

Quantitative models are the computable embodiment of the qualitative appreciative models of a dynamic situation: they are necessarily incomplete because the 'entire' situation is beyond understanding of the constraints of artificial boundaries. How computable models are constructed, their pitfalls and what can be learned from them is a matter of both interest and concern discussed next.

1.6 Algorithmic World

An algorithm, or a set of them, lies at the heart of any method used in FTA that involves a computable model. What then is an 'algorithm'? An algorithm is a precise step-by-step calculation procedure: it is an effective method expressed as a finite list¹ of well-defined instructions for calculating a function. Algorithms have become ubiquitous as the so-called app revolution has made so many consumer products depend on computation for their operation. Each 'app' is a representation of the product's designer's model of how that product ought to work. To reach this state of affairs, the procedure outlined in Fig. 1.4 has been gone through either knowingly or unknowingly.

The transition from the linguistic appreciation of the situation is complex and, as already pointed out, requires intense handshaking throughout and, if an 'app' is involved, that may involve both software versus firmware or both. Sadly, the rise of

¹http://en.wikipedia.org/wiki/Algorithm-cite_note-1.

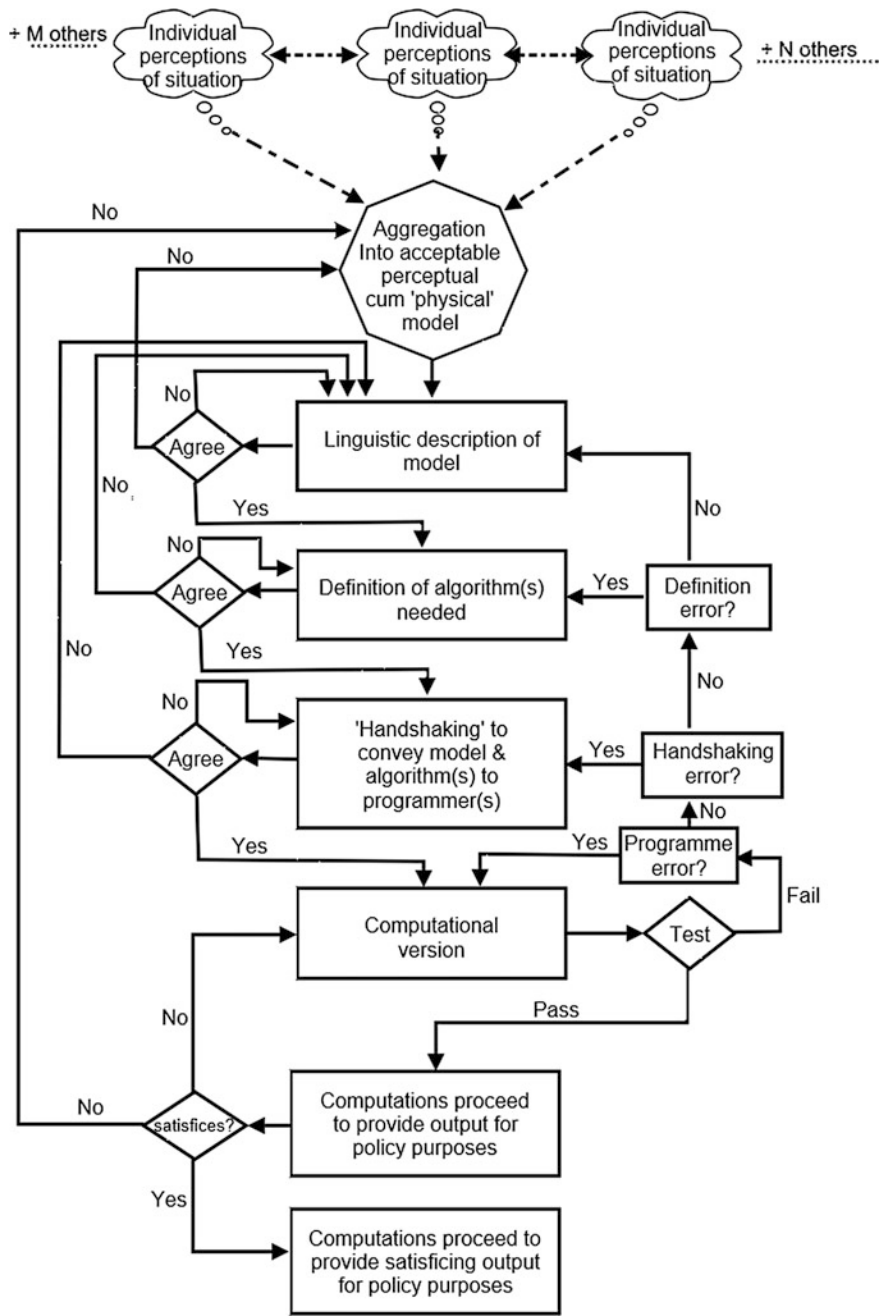


Fig. 1.4 From individual perceptions to computable policy model—a flow diagram

the world of ‘apps’ removes the necessity to understand what is going on behind the screen. Approximations and shortcuts are often used by programmers and the nature of the underlying model remains hidden, so that questioning the output lies in the land of intuition else the output is subjected to blind acceptance. The proliferation of ‘apps’ lies in the human value now placed on immediacy often at the expense of security and privacy, and quality of the information created.

1.7 Big Data World

What is ‘Big data’? Big data may be described as ‘an all-encompassing term for any collection of data sets so large and complex that it becomes difficult to process using traditional data processing applications’ (Wikipedia): this amounts to the accumulation of very large amounts of raw textual, numerical and graphical data collected by any means whatsoever that is capable of being digitized. Big data is, in that sense, ubiquitous with the prospect of transforming FTA. The revelations of the ‘Snowdon papers’ has done a great deal to, somewhat savagely, change the polity’s perceptions of itself, of government security agencies throughout the world, and the probability that previously treasured privacy has been given up freely by large segments of people of all ages through the arrival of cybernetic social networks: a much simplified picture of how deeply the appetite of ‘big data’ is being fed can be gauged from Fig. 1.5.

Perhaps the most astonishing development has been the rise in the number and depth of data-collecting devices. Any individual may now clothe himself/herself so as to become a mobile and unique data source. In addition with the powers now being enacted, governance organizations are changing from local through national to global. Some of these powers are known others are not; falling into the category of unknown knowns: the only surety is that privacy is no longer a feature of human societies. At one time, the huge volume of data in ‘big data’ would not have mattered greatly as it could not be processed for any real purpose: that too has now become a fiction as the combination of computing power and effective processing procedures (algorithms) of great power has been created. Can FTA now deal with software sciences? Or is it routed elsewhere? It is only a matter of time before at least some if not all of these algorithms are embedded in ‘apps’ for common use changing the appreciation of security of information, of social interaction and of social control.

It is for the foregoing reasons that ‘big data’ has become important while the internationalization of all of them has introduced a new dimension through, for example, Webinars that enable management of international affairs in ways quite different to the past (e.g. Issl’s management of its corporate intentions and image through the social networks). ‘Big data’ arrived during World War II when signal interception and deciphering became such an important weapon. Who uses and controls big data is a major preoccupation in all polities now that it is an open ‘secret’ that companies, governments and NGO’s make use of ‘big data’ for

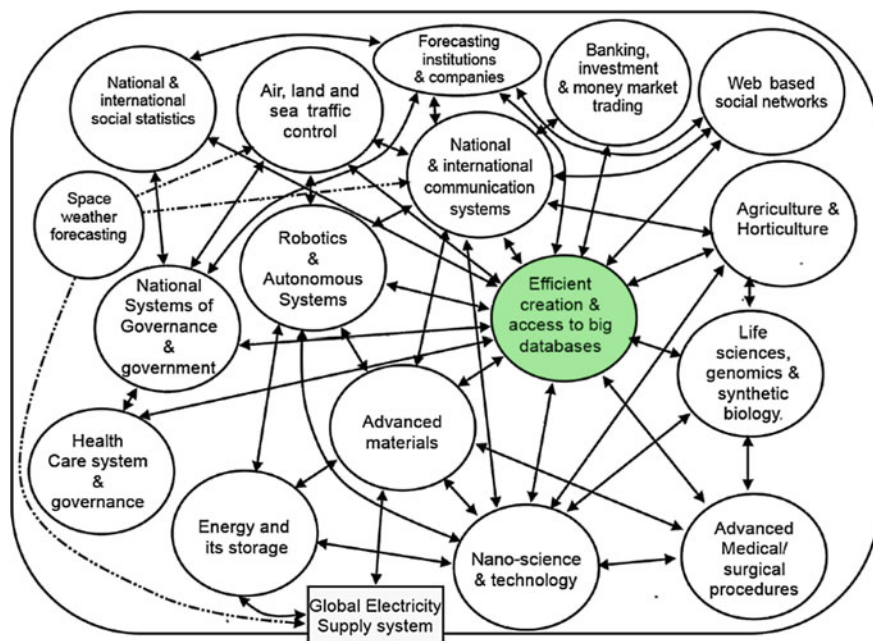


Fig. 1.5 Some elements 'feeding' to 'big data'

purposes that range from legitimate to questionable. More contentious is that storage and control of access to 'big data' is often in the hands of a relatively select set of organizations, some public and some private, where the latter has considerable financial muscle. 'Big data' runs throughout the STEEPV acronym, so that its values are ubiquitous even if access to it is limited through either commerce or processing and interpretation capabilities. The latter relates to software capability and its quality, neither of which can be taken for granted.

1.8 World Duo of Algorithms and Big Data

Earlier comments lead to the inevitable conclusion that the combination of immense computing power, united with similarly huge advances in algorithm design and programming, all married to 'big data', create a duo that may come to dominate human decision-making with influences throughout the human and natural worlds. There is plenty of evidence to that effect. For example, the UK revenue authorities HM Revenue & Customs (HMRC) have long collected an array of information on individual financial affairs. HMRC's IT capabilities, through its Connect system, developed by BAE Systems, can create taxpayer profiles either singly or in groups from 'big data' collected globally (if necessary) to enable identification where tax

evasion may be occurring and to do so quickly. Similarly, algorithms are being used to define city areas where criminal activity is likely to be rife to facilitate anticipatory police operations. There is also a plethora of modelling of national economies, climate and weather to mention only three of the better known spheres where the ‘duo’ may be putting human judgement into diminuendo.

The duo has now gained traction through governments and major corporations through conventional modelling: it is clear that the influence of the duo on all life is not a mere assertion. Whitehead’s emphasis on misplaced concreteness points directly to the fallacy embedded in all modelling that it does not and probably cannot represent the real world. The duo cannot create the real world out of the imperfections of modelling nor can it identify more than the model’s framework will allow. The danger is that modelling through its boundaries and the duo close off real-world options while use of the computed options implies attempting to force the real world to conform to the unreal world of computation, a world governed by the nature of algorithm design, programming (with its human fallibilities’) and the frameworks imposed by ‘big data’ structures. In this way, the duo is already setting boundaries, real and unimagined, un-noticed and unconventional, around all life introducing the certainty that the duo’s influence on policy making will endure for decades into the future. The notions of ignorance and precaution are ever present.

Privacy may be only the first casualty, intended or unintended, while opinion and belief formation may not be far behind. Freedom and control of the polity are already deeply involved through matters relating to security, freedom of movement and to many individual privileges and rights, to disease control and to the control of organized crime on all scales.

What all the foregoing means for FTA is explored next.

1.9 FTA for the Future

The present section presents two propositions. The first deals with the nature of FTA, and the second concerns the world that FTA is now embedded in and will remain for decades.

The claim to a future orientation for TA is an oxymoron. Once an idea has been expressed in public space, it is no longer in the future but inhabits whatever time space one chooses. It may seem pedantic to make this distinction but the act of recognizing something not previously known has some deep implications for the conduct of FTA. First, the recognized information will lie somewhere in the taxonomy of ignorance described earlier: this will have implications for the directions of learning: the boundaries, which by inference must be sympoietic to allow the entry of new information, will need revision to enable bridging to policy making while embracing uncertainty, complexity and creativity. Second, the boundary between ignorance and knowledge will change implying that the shift is real and

not pseudo. Real shifts in the frontiers of ignorance are complex and difficult to recognize.

The second proposition is derived from the struggle between human judgement and the algorithm-‘big data’ duo. The struggle began with the advent of computing machinery embodied in Babbage’s mechanical computing machine but really became obvious following Turing’s 1936 paper that set the scene for all modern digital computers. **Will the ‘algorithm-big data’ age be a frightening jobless dystopia?** Three quotations set the scene:

Between now 1984, business and government use extraordinary advances in computer technology to file and collate ‘personal’ facts about private citizens (Michael (about 1962))

..... little questioning is apparent anywhere in relation to computers a major goal for computer technologists is to put new skills back into the hands of individuals rather than to continue to remove them from employment:.... From ‘Computers and You’ (Loveridge (1983))

‘finding employment for these [displaced] workers will be the “defining issue for the global economy in the decades to come. It’s a race between computers and people – and people need to win” Eric Schmidt, Chairman, Google (2014 Sunday Times Business, 2 February)

The proposition points to some fundamental questions about the future of human life and of *all* life as human judgement and/or the duo engage ever more closely. It is this evolving engagement that is reshaping decision-making in many spheres and will shape the nature and content of FTA.

FTA is application oriented, and it is a real-world activity involving threads in all of the STEEPV themes. It is plagued with all the aspects of ignorance along with ambiguity, paradox, complexity that inevitably are simplified through setting boundaries, real or imaginary, to enable appreciation of the situation. Normal accidents (Perrow 1984) of every conceivable kind are only to be expected when the situation is far from equilibrium which those subjected to FTA studies usually are. FTA needs to step away from the time-honoured addiction to methods of analysis that have not changed much in several decades. The need is to move towards the investigative ideas embodied in ‘due diligence’ with their flexibility; emphasis on the entire STEEPV set and with probing questions that evolve as appreciation of the situation and its dynamics reveal themselves. Appreciation begins and ends in the top level in Fig. 1.4 where probing dialogue occurs before a linguistic model, based on common ground and agreed boundaries, begins to emerge and to be formulated as a model locking out elements of the appreciation that might prove to be the keystone of the situation. Fixed checklists are not suitable for appreciation of a situation.

For FTA, the borders between the themes of the STEEPV set have largely, if not entirely disappeared. FTA therefore needs to become investigative rather than analytical. In the business and investment world, this requirement often is a legal one achieved through *due diligence*. The proposition is for FTA to embrace the principles of due diligence in a modified form to encompass the virtual disappearance of disciplinary boundaries. If this sounds like a return to the principles set

Table 1.1 Requirements of due diligence for (F)TA

STEEP element	Due diligence representation	Dominant feature
Social	Expectations and realities of individuals and of groups of individuals	Social cohesion
Technical (includes science, technology and engineering)	Influence of engineering, science and their thought processes and outcomes on life	Fail-safe versus safe fail
Economics	Business, industry including challenges to conventional economic 'theories'	Ecological economics and purposes of industry
Ecology	Principles of sustainability underpinned by laws of thermodynamics	Entropy
Politics	Governance, law and compliance	Rules regarding freedom and responsibilities
Values	Basis of societies beliefs and its unspoken 'social contract'	Argumentation and legitimization of 'mores'

out by Huddle (1972) and Dale and Loveridge (1996), then so be it. What then is due diligence? And how does it differ from analytical processes that are essentially defined algorithmically even if that is not declared?

The UK Business Angels Association has advanced notions of due diligence for start-up small businesses: with reasoned modification, these can create an appreciative mind for FTA practitioners. The guidance offered by the UBAA has its necessary limitations which, it is suggested, can be made relevant to FTA as shown in Table 1.1.

Due diligence is a language-based way of systemically and intuitively researching, verifying and appreciating a situation in the context of the taxonomy of ignorance. Sometimes, it is based on legal requirements, often it is not, but may shape legislation later. While the term originated in the business world, where due diligence is required to validate statements about the business, the goal in FTA was to ensure that every endeavour is made to assess the influence of technology within the agreed boundaries with the definition of TA offered by Dale and Loveridge. Will new skills be needed for this form of FTA? That is a 'big maybe' to look at next.

1.10 New Skills Required for the Future of FTA

'We think only through the medium of words. Languages are true analytical methods.... The art of reasoning is ... language well arranged' Lavoisier (1790): that is the point of the topmost level in Fig. 1.4. The algorithmic computation that follows limits reasoning unless there are very strong feedback loops: without these algorithms and computers kill reasoning. Until very considerable strides are made

in computer-based reasoning, there are subtle but inevitable dangers in slavishly following the output from the duo. Until then, computer-based models will say a great deal about the interaction between the model and how the computer copes with its algorithms, and the programmer's interpretation of them: these subtle influences will remain. ***Reasoning about ignorance is an unfamiliar skill.***

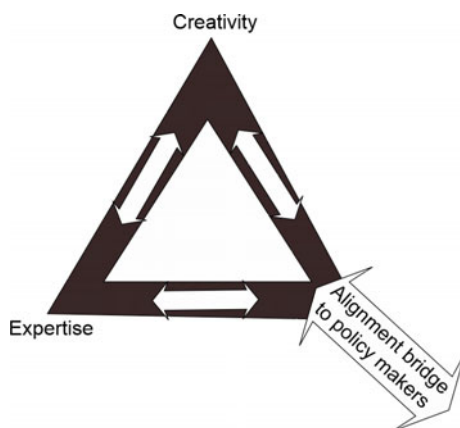
Due diligence is an intensely practical investigation but will remain a prisoner of ignorance in its many guises. It will always depend on a mixture of subjective opinion and quantitative data that ought to be measured against requirements of the NUSAP system of assessing the quality of data. ***Understanding numbers and the quality of data is another required skill.***

Dalkey's description of subjective capability may be reinterpreted as a relation between expertise and creativity; these can be placed at two corners of a triangle. The third apex of the triangle is concerned with interpreting the outcome of the tension between expertise and creativity, into the policy-making processes; this has been termed alignment (see Fig. 1.6), with the implication of interaction (Cameron et al. 1996).

The triangular representation is preferred as none of the three vertices is in opposition, but all work through a creative tension. Effectively Interaction/Alignment is a process of crossing a bridge between *two worlds*.

FTA practitioners need the ability *to engage in speculation, as defined by Dalkey: this is crucial; just as crucial is the ability to articulate that speculation in the form of substantive, but subjective opinion. However, radical insights into the future require the willingness to engage in conjecture, which will involve creativity*. The natural tension between expertise and creativity can bring important shifts in opinion that needs to be introduced into the policy process, effecting some tentative alignment, or bridge-building between radical opinions and the existing legitimated opinions held in the polity: this is the purpose of due diligence.

Fig. 1.6 A notional FTA—
policy bridge



FTA as due diligence is concerned with applications as situations. Due diligence in this context is the ‘intellectual task of articulating our problems [situations] of living’ (Maxwell 1984) with the intention of proposing and criticizing possible solutions and human actions. It is not concerned with reductionist problem-solving but with the dynamism of life itself. It is this dynamism that converts the notions of the problems of living into life as the series of ‘situations’ that it really is and in which problem-solving is but a small and double-edged procedure. *Situations are systemic and need to be thought of in the appropriate way*, involving the uncertainties of fuzzy boundaries; interdependencies that convert complications into complexity; the consequent creation of emergent situations that (it is claimed) ‘cannot be anticipated.’ *Thinking in terms of dynamic situations is a required skill.*

FTA conducted as due diligence needs an integrator(s) who is/are the key person (s) capable of ‘gluing’ the many aspects of due diligence together. *People always come top of the list of required skills in the venturing world which is where FTA really fits.* Often the notion of interdisciplinary or transdisciplinary teams are seen as the required way of working; sadly it is not. Due diligence *requires excellence in breadth and depth in the core people: this is a scarce resource requiring knowing how to learn, how to think and numeracy in depth.* Figure 1.7 illustrates this using set theory based on nanotechnology.

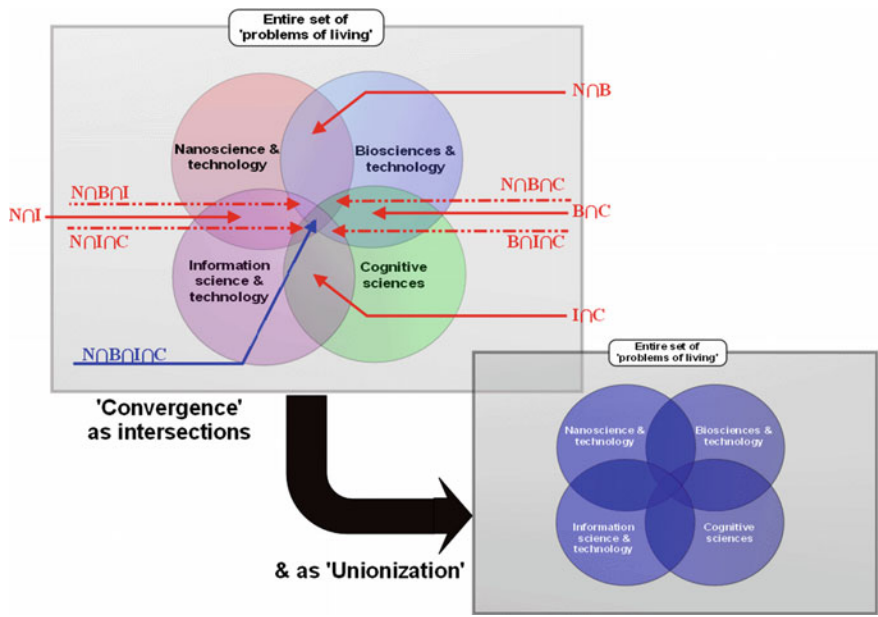
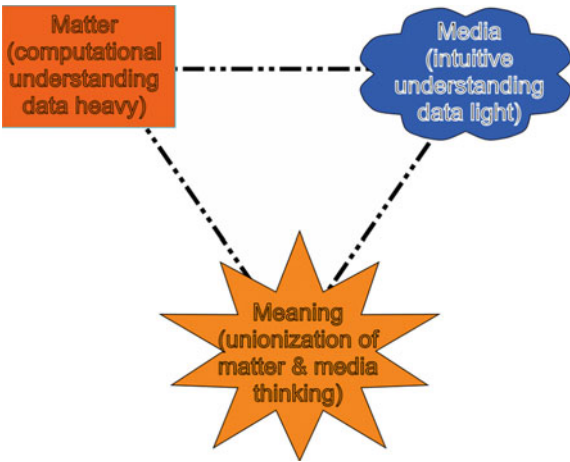


Fig. 1.7 Convergence through interdisciplinarity versus unification via excellence in breadth and depth

Fig. 1.9 Unification of modes of reasoning



- Reason about ignorance
- Understand numbers and the quality of data
- Leverage creativity
- Think in terms of systemic situations
- Build excellence in breadth and depth
- Build the necessary bridge to policy and decision makers.

Due diligence principles will guide an evolving understanding of the dynamism of the situations perceived through a process of questioning and reasoning freeing FTA from fixed methodologies, thus allowing new information and learning to take place via a sympoietic understanding of complex systems. Two essential shifts will then take place:

From...	... To
Unrevealed biases and describing extrapolations of the present in the future	Exposing anticipatory assumptions and describing discontinuities and ‘unknowns’
Addition to methods and the use of checklists and analytical processes, defined algorithmically	Investigative ideas with emphasis on the entire STEEPV set with probing questions evolving as appreciation of the situation and its dynamics grows

The relationship between FTA and the ‘algorithms and big data’ duo needs examination. Due diligence allows questioning and reasoning, according to Fig. 1.1, whereas algorithmic methods may not. Building such ability may support looking outside familiar systems because of the emphasis on specialism in breadth and depth in preference to interdisciplinarity.

In 1996, technology assessment (TA) in its original form faced a crisis (in the sense of a turning point) as indicated by many authors in a special publication

(Loveridge 1996). Even though many of the individual authors claimed cultural diversity influenced how TA was conducted the underlying themes tended to be in problem based and methodological silos. In the past 20 years, it has more than ever become clear that subject silos no longer exist and that their ‘invisible walls’ have melted away in the face of the almost infinite variety (Ashby 1956) of information and data flowing publicly from the World Wide Web (WWW); the social (and other) networks it enables, and many other sources of data as illustrated earlier (Fig. 1.5). Soddy (1922), Bertalanffy (1960), Ackoff (1974), Checkland (1981), Maxwell (1984) and Loveridge (2009), among others, have all pointed, in different ways, to the need to accept that the STEEPV set is dynamic and that ‘solutions to problems’ become non-viable quickly and often before a study of them is complete. FTA then needs to:

- Adopt the notion of situations and their dynamism
- Adopt the principle of amelioration
- Reject the notion of problem-solving that yields solutions to well-specified problems that are not typical of the real world
- Encourage people to become, on the basis of learning how to learn, how to think and to appreciate numeracy in appropriate ways
- Create appreciative capabilities in breadth and depth to cope with the crisis in which FTA is already embroiled brought about by the algorithm-big data duo
- Adopt due diligence as a learning-based investigation that eschews structured checklists and similar questionnaires that might constrain what approximates a forensic investigation that requires learning.

1.12 Conclusions

Digital technologies have penetrated deeper and ever more quickly all forms of life on Earth: after 50 years of warnings, this has taken human societies by surprise and without much questioning of its implications. For FTA to supply that questioning, its mindset needs to change as indicated in the preceding discussion. The urgency for this is exemplified by Schmidt’s express view that it is a race between computers and people and it is one that living systems need to win.

References

- Ackoff, R. L. (1974). *Redesigning the future: A systems approach to social problems*. John Wiley Interscience.
- Amara, R., & Lipinski, A. J. (1983). *Business planning for an uncertain future*. Pergamon Press.
- Ashby, R. (1956). *An introduction to cybernetics*. Chapman & Hall.
- Bertalanffy von, L. (1960). *Problems of life*. Harper ‘Torchbooks’.

- Boettinger, H. M. (1969). *Moving mountains or the art and craft of letting others see things your way*. Macmillan.
- Cagnin, C. H., Amanatidou, E., & Keenan, M. (2012). Orienting EU innovation systems towards grand challenges and the roles that FTA can play. *Science and Public Policy*, 39(2), 140–152.
- Cagnin, C. H., & Loveridge, D. (2012). A framework, with embedded FTA, to enable business networks to evolve towards sustainable development. *Technology Analysis & Strategic Management*, 24(8), 797–820.
- Cameron, H., Loveridge, D. et al. (1996). Technology foresight: Perspectives for European and International Co-operation. Final Report to CEC DGXII, April.
- Checkland, P. (1981). *Systems thinking, systems practice*. John Wiley.
- Dale, A., & Loveridge, D. (1996). Technology assessment—Where is it going? *International Journal of Technology Management*, 11(5/6), 715–723.
- Dalkey, N. C. (1969). *The Delphi method: An experimental study of group opinion*. RAND Corporation.
- Dempster, B. (1998). *A self-organizing systems perspective on planning for sustainability*. B.Sc. Thesis, University of British Columbia, Vancouver, Canada.
- Dempster, B. (2000). Sympoietic and autopoietic systems: A new distinction for self-organizing systems. In *Proceedings of the World Congress of the Systems Sciences and ISSS 2000*. Toronto, Canada.
- Fredrickson, B. L., & Losada, M. (2005). Positive affect and the complex dynamics of human flourishing. *American Psychologist*, 60(7), 678–686.
- Funtowicz, S. O., & Ravetz, J. R. (1990). *Uncertainty and quality in science for policy*. Theory and decision library, series A. Kluwer Academic Publishers.
- Holling, C. H. (1977). The curious behaviour of complex systems: Lessons from ecology. In H. A. Linstone & W. H. C. Simmonds (Eds.), *Futures research: New directions* (pp. 114–129). Addison-Wesley.
- Huddle, F. P. (1972). *A short glossary of science policy terms*. Washington: Science policy Research Division, The Library of Congress, US Government Printing Office.
- Lavoisier, A. M. (1790). In W.H. Brock, (Ed.), 1992, *The Fontana History of Chemistry*, p 115
- Losada, M. (1999). The complex dynamics of high performance teams. *Mathematical and Computer Modelling*, 30(9), 179–192.
- Losada, M. (2001). The art of business coaching. In *Second General Conference of the Specialization Course*, Brasilia.
- Loveridge, D. (1983). Computers and you: An essay on the future. *Futures*, 15(6), 498–503.
- Loveridge, D. (Ed.). (1996). Special issue on technology assessment. *International Journal of Technology Management*, 210 p.
- Loveridge, D. (2009). *Foresight: The Art and Science of Anticipating the Future*. Routledge
- Maturana, H. R., & Varela F. (1980). *Autopoiesis and cognition: The realization of the living*. Dordrecht, Holland: D. Reidel.
- Maturana, H. R., & Varela F. J. G. (1997). *De máquinas e Seres Vivos - Autopoiese: a Organização do Vivo* (3a ed.). Porto Alegre: Editora Artes Médicas.
- Maturana, H. R. (1998). *Da Biologia à Psicologia* (3a ed.). Porto Alegre: Editora Artes Médicas.
- Maxwell, N. (1984). *From knowledge to wisdom: A revolution in the aims and methods of science*. Basil Blackwell.
- Michael, D. (1962). *Cybernation: The silent conquest*. Santa Barbara: Center for the Study of Democratic Institutions, February [Reprinted in *Computers and Automation*, March 1962, 11, 3, pp. 26–42].
- Perrow, C. (1984). *Normal accidents: Living with high risk technologies*. Basic Books.
- Roberts, J. (2012). Organizational ignorance: Towards a managerial perspective on the unknown. *Management Learning Advance Online Publication*. doi:[10.1177/1350507612443208](https://doi.org/10.1177/1350507612443208)
- Rocha, I. (2003). 'Gestão de Organizações: Pensamento Científico, Inovação, Ciência e Tecnologia, Auto-Organização, Complexidade e Caos, Ética e Dimensão Humana,' São Paulo: Editora Atlas S.A.
- Schmidt, E. (2014). Sunday Times Business, 2 February.

- Soddy, F. (1922). *Cartesian economics: The bearing of physical science on state stewardship*. Hendersons.
- Stirling, A. (2008). Science, precaution, and the politics of technological risk: Converging implications in evolutionary and social scientific perspectives. *Annals of the New York Academy of Sciences*, 1128, 95–110.
- Turing, A. M. (1936). On computable numbers, with an application to the Entscheidungs problem. *Proceedings of the London Mathematical Society*, 42, 230–265 (2, 1937).
- Whitehead, A. N. (1925). The fallacy of misplaced concreteness, pp. 64, 72 (The error of mistaking the abstract for the concrete).
- Zohar, D. (1990). *O Ser Quântico: Uma Visão Revolucionária da Natureza Humana e da Consciência Baseada na Nova Física*. São Paulo: Editora Best Sellers Zohar.

Anticipating Future Innovation Pathways Through Large
Data Analysis

Daim, T.U.; Chiavetta, D.; Porter, A.L.; Saritas, O. (Eds.)

2016, XVIII, 360 p. 141 illus., 108 illus. in color.,

Hardcover

ISBN: 978-3-319-39054-3