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Decision Economics: Minds, Machines, and their Society

 Springer

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In remembrance of **Stefano Terzi**, co-author of Chapter 12 of this book,
esteemed colleague recently passed away. A tribute to his memory and legacy.

(Stefano's three co-authors, along with editors)

As dark misery settles down on us, and our refuges of lies fall in pieces one after one,
the hearts of men, now at last serious, will turn to refuges of truth.
The eternal stars shine out again, so soon as it is dark enough.

(Carlyle, 1843, p. 251)

DECON, Methodological Pluralism and the Consilience of Knowledge

When we commenced putting this special book together, we sought advice from a number of our colleagues, who are all experienced economists and scientists worldwide and, above all, have provided us with many constructive comments, insights, and reviews along the way. After all is said and done, we have ended up with thirty-eight contributing authors in this new edited volume—excluding editors—and we would like to thank all of them very much because there is no doubt that their experience and dedication have given this book a much broader and more interesting perspective even this year.

In a time, indeed, when it is generally hard enough to keep abreast of novel and non-rhetorical literature in most research fields, the publication of peer review research papers, such as the collected papers in this special book, is something to be undertaken neither unadvisedly, nor too lightly, and nor wantonly. It is against this background of increased attention to research that the scientific initiative on Decision Economics (also known as DECON) has allowed the emergence of a novel discipline (see Bucciarelli, Chen, & Corchado 2020) as well as several explorations within and around economics—and their implications—by distinguished and pioneering scholars, whilst professionally stepping up and undertaking quite a few tasks and work streams that were not envisaged at the start, in 2015, when DECON was conceived. In this regard, the persistent positive reinforcement received over the past five years largely helped and still helps to overcome that certain, specious distaste which—regrettably and, we believe, largely driven by ‘other’ considerations—some of us still feel for special book productions and brought this volume, too, to the point of no return. It is true that some exploratory papers might appear among an unconscionably awkward selection of publications for anyone wanting to follow them up with an established logical or metalogical interpretation. However, it is equally true that it is a question of contextualising them within a novel discipline—Decision Economics, precisely—with the ambition of sharing advancements, ideas, and experiences in different research areas, encompassing several interdisciplinary topics while seeking to intercept key dynamics that will reshape the very near future of research in economics and, perhaps, are already reshaping it in the present-day.

It appears, furthermore, that the main benefits and characteristics perceived by dozens of authors—about two hundred authors have seen their works published with DECON in the past five years, first, as a special session originally scheduled as part of the annual DCAI meeting to help bridge the gap, where cognitive sciences meet economics, then as an autonomous conference—were the encouragement to critically analyse their working papers during the strict peer-reviewing process, and to generate and propose new or novel ideas in respect of science achievements and scientific conceptions, first of all mathematical in nature or, in any case, analytical, cognitive, computational, evolutionary, and experimental. Consistent with what we have been supporting for some time, among other issues, economic theory, game theory, and, *inter alia*, mathematical statistics are all increasingly becoming algorithmic sciences (see Velupillai 2009; see also Gács et al. 2001; and Nisan et al. 2007). This awareness allows fostering the proposition of new ideas and new methodological approaches in the same breath—a kind of moral duty for a scientific community worthy of its name—and facilitating the emergence of new possible solutions to long-standing and unresolved problems in science, management, policy-making, and ordinary life.

In editing this special book, indeed, we had considered the basic interplay between mathematics and cognitive methods on the one hand, and emerging economics on the other as a rich field of research with a wide range of domains of applications, many of which are epistemologically relevant and underpinned by classical recursion theory along with its applied approaches—complexity theory, but algorithmic information theory as well—and, sometimes, proof theory (see Chaitin 1987; and Li & Vitányi 2019 [1993]). More specifically, and amongst many other research accomplishments, one has to answer some obvious questions and concerns in considering the development of a mathematical theory, which is primarily geared towards cognitive economics (see Chen 2016), be it computational, logical, or merely conceptual.

For instance, a majority of scholars would have given a clear and unwavering answer concerning the fundamental role of mathematics, that is, it is used for representing and solving problems in a multitude of domains. Other scholars are not quite so certain that this is a—or one of the—primary role of mathematics as mathematical (neoclassical) economists would like to believe shedding more heat than light by referring to rational mechanics (see Leijonhufvud 1973; Cohen 1993; see also Gillies 2004; and Lawson 2004). First and foremost, mathematics and meta-mathematics provide abstract languages in which researchers can attempt to state some cognitive and socio-economic laws accurately and consistently. Secondly, mathematics—and its serious concern with logic and metalogic—can be used as a possible source of cognitive and socio-economic challenges in order to offer promising theoretical explanations, as well as an opportunity to establish discriminant validity between different concepts, in a continuous interplay of mathematical, cognitive, and socio-economic ideas. Significant cognitive and socio-economic concepts usually led to an enrichment of mathematical concepts.

Vice versa, a concept that occurs naturally in diverse areas of mathematics—such as the induction principle or the principle of mathematical induction, as well as the principle of recursion for inductively defined relations—might have important cognitive, socio-economic, and complex interpretations. Accordingly, one of the most significant and lesser-known achievements of Decision Economics is that it helped—in its own small way—break down barriers between academic departments, or sterile disciplinary enclaves with their atavistic and bare antagonisms, facilitating the communication between many researchers, especially the youngest ones, and the sharing of knowledge to move beyond labelling scholars, without resorting to *a priori* classifications for their own sake.

With mathematics, cognitive, and evolutionary methods as the glue, the legacy on which DECON was founded—as well as the various experiences of its founding fathers—also demonstrated successful collaboration between research centres, laboratories, small businesses, corporations, international agencies, university departments, and institutions such as the United Nations. All this conceded, we are currently experiencing similar achievements and sharing similar challenges, although some research fields can seem elusive, peripheral, or unrelated with all that is still going on in the world these days. Above everything and everyone, therefore, the common denominator of the aforementioned interdisciplinary topics is science in the round with its shared tools and methodologies, certainly not dogmas, nor single disciplinary fields tending to one's own knitting—not only figuratively—or tooting one's own horn.

Decision Making in a Tribulation Time

This year, furthermore, the admirable resilience of the scientific community, as well as more or less young scholars from every country infected by SARS-CoV-2 and the related Coronavirus disease (COVID-19) throughout the current pandemic, has been—and still is—an endless source of inspiration, unfolding resilient and uncertain times especially for that part of the world that had little or no familiarity with them—when the pandemic broke out in March 2020 roughly, the individual contributions that make up this book had already been submitted and peer-reviewed. Months later, many questions abound, some of which have yet to be addressed by research. How communities and significant behavioural changes can help mitigate the impact of global health crises like the one we are facing? As the world approaches three million deaths from the novel Coronavirus recorded worldwide (when this book is published, this number will sadly be largely exceeded this figure), we should confront that scientific 'community' is a term that resonates strongly, but does it really matter to anyone?

As a group of academicians who pursue and share a culture of intellectual social responsibility on a daily basis, we editors strongly believe that it matters so much to us all, scholars and scientists, stressing its continuous construction, being an essential part of who we are, where we are going, and what we belong to. Since its

founding in 2015, Decision Economics has benefited from the international encouragement and positive reinforcement it has received to sustain its mission to provide a global, community-wide initiative. Specifically, the outpouring of support that DECON has received to assist in its mission has been the epitome of ‘community’ particularly in 2020. Matters are not so simple, however. In any case, with the history that always repeats itself, over and over again, it is interestingly enough to see that something either has not changed much or we have learned from the past very limitedly and slowly. If we are not beguiled by the surface of the modern civilisation, underneath it we can see that it remains as fragile no matter how much we have clothed it with sciences and arts. As Hans Zinsser (1878–1940) already pointed out in “*Rats, Lice, and History*” (Zinsser 1935):

But however secure and well-regulated civilized life may become, bacteria, protozoa, viruses, infected fleas, lice, ticks, mosquitoes, and bedbugs will always lurk in the shadows ready to pounce when neglect, poverty, famine, or war lets down the defenses. And even in normal times they prey on the weak, the very young and the very old, living along with us, in mysterious obscurity waiting their opportunities. [...] Nature, as Goethe puts it, runs its course by such eternal and necessary principles that even the gods themselves cannot alter them. The most that the scientist and the artist accomplish is new understanding of things that have always been. They “create” a clearer perception. They are both, in this sense, observers, the obvious difference being that the scientist impersonally describes the external world, whereas the artist expresses the effects which external things exert upon his own mind and heart. In both cases, the more generally applicable the observations, the greater is the science or arts. [...] With the gradual development of experimental method, those who were curious about the phenomenon of life became, by the very precision of their observations, more modest in regard to speculation. [...] In the earlier days of the Black Death mass aberrations became apparent in the sect of the flagellants, who joined in brotherhoods and wandered by thousands from city to city. Later, for a time, it took the form of persecution of the Jews, who were held guilty of the spread of disease. The criminal proceedings instituted against the Jews of Chillon were followed by a degree of barbarism throughout Central Europe that can only be regarded as a part of the mass insanity of which the dancing manias were a manifestation. These manias are, in many respects, analogues of some of the political and economic crowd hysterias which have upset the balance of the civilized world in modern times. (Zinsser 1935, pp. 13–14; 21–22; 51; 81).

Similarly, about the mania mentioned in the last of Zinsser’s excerpts above, Charles Mackay’s (1841) book “*Extraordinary Popular Delusions and the Madness of Crowds*” remains to be a classic still relevant to our troubled times. His chapter on witch-hunting can be read even better in light of modern concerns, and we sometimes cannot help but wonder whether the difference between locusts and humans may be much smaller than originally assumed: Humanity is still witnessing it, like Mackay’s people of Leeds and Milan. In a nutshell, we are having challenging and uncertain times, putting a strain on all our human frailty. Perhaps we should reconsider the theory of black swan events (see Taleb 2007), reminding how fragile humanity is, despite what it may look like from the outside, and how much we might as a ‘community’ to establish a more human and fairer basis for development and sustainability worldwide. If there ever was a wide ‘community’ impact

and a societal wake-up call, COVID-19 infectious disease was it. If so, how will our post-pandemic world be emerging and rebuilt? In a still-debated sea change, the current pandemic forced us—sometimes out of sorts—to reinvent and rewire work ‘smartly’ at one fell swoop, correct hygienic misbehaviours, and meanwhile double-down on our understanding of the root cause and spread of this infectious disease. Straining at the leash to get out and about after months of lockdown on a large scale, what will the world look like after the COVID-19 plague and what have we learned about the way in which we make critical decisions as was the case especially in the last months? Will life after lockdowns for most return to how it was before there were restrictions and we were limited with what we could do?

Looking at decision-making, indeed, we wonder how decisions can be made by anticipating possible innovation networks / innovation event trajectories with different innovation capabilities and management perspectives and developing smart scenario responses. And above all, what can we learn from virus outbreaks such as the current one as well as those of the past? Despite the advent of effective vaccines and targeted treatments, infectious diseases remain a major cause of morbidity and mortality. In recent decades, the emergence of new pathogens (e.g., HIV, SARS, new strains of influenza, etc.) as well as the persistence of others (e.g., malaria, tuberculosis, etc.) have generated growing concern and triggered extensive efforts to develop strategic plans and create predictive models for humanity to be able to face new infectious threats through sensitive decision-making processes with the use of scarce resources (e.g., vaccine doses and budgets) available to policy makers.

Standard approaches for identifying optimal strategies for the control of infectious diseases employ mathematical models or simulation of the spread of diseases both to compare the performance of a limited number of policies and to select the one with the best-expected result. Static policies specify a predetermined sequence of actions to be taken such as, for example, keeping schools closed between 10 and 12 weeks after the onset of a flu epidemic, and are simple to evaluate and optimise using epidemic models. In practical terms, however, these policies require a decision-maker to engage in a sequence of interventions at the start of an epidemic that are not structured to facilitate decision making that responds to the most recent epidemic data. It would be better to use the epidemic data that are gradually collected, for example, on hospitalisations, in order to dynamically update the decisions to be made. Policies that make recommendations based on the latest epidemic data are defined as dynamic as they do not specify the timing of future interventions and use epidemic observations to guide the use of control interventions.

In spite of this, dynamic policies have gained less attention in the scientific literature because defining and optimising these policies is more than a challenge and it involves a huge methodological leap. Indeed, the observations that can be made during epidemics—and the related data—with implications for emergency management are very numerous (e.g., hospitalisations, mortality from disease, availability of vaccines and treatments, etc.) while the measurements made day by

day on distinct populations must be verified and repeated continuously over time. It is therefore possible to define a large number of dynamic policies, each of which differs from the method by which the collected set of observations is used to inform decisions. By the way, a key question may be how dynamic policies can be constructed using simple and easily obtainable measures of epidemic status and resource availability that can still inform—roughly—optimal decisions during outbreaks. This means that mathematical models are needed and that no doctors guide political decisions in the face of an epidemic, but mathematical brains equipped with the highest intelligence and calculation skills on big data and artificial intelligence.

Naming and Constituents of the Book

Before we go to each part, let us first look at this book as a single coherent entity. The book is christened as *Decision Economics: Minds, Machines, and their Society*. The leading title, *Decision Economics*, remains to be the same as two previous editions published as a result of DECON 2018 and DECON 2019. In fact, this is the same leading title that we started to use in 2016 when DECON was still organised as special sessions under the umbrella of DCAI. For those who have followed us since the very beginning or even for those who just joined us later may be convinced that we are building a new Society characterised by a new disciple through this emblem, DECON. For what DECON stands for, Decision Economics is an emerging new discipline after long interdisciplinary interactions among economics, computer science, artificial intelligence, psychology and neuroscience, mathematics, and other social and cognitive sciences. In a sense, it is an extension of Simonian economics; the legendary connection is clearly manifested in the publication of DECON 2016 and 2017, namely, “*Decision Economics: In Commemoration of the Birth Centennial of Herbert A. Simon*” and “*Decision Economics: In the Tradition of Herbert A. Simon’s Heritage*”.

By carrying on the legacy of Herbert A. Simon, specifically, his enduring interdisciplinary efforts, Decision Economics places decision-making in an incessantly evolving and enlarging interdisciplinary framework (and design) so as to distinguish itself from how mathematical (neoclassical) economics treats this subject. All things considered, economics participates in interdisciplinary encounters in various ways and at diverse levels and meta-levels, affecting other disciplines and being affected by them in turn. With a much broader perspective, we naturally have a plethora of dimensions to summarise what has been done in each edition. Hence, in 2018, as an example, *the term of the year* was “*Designs, Models, and Techniques for Boundedly Rational Decisions*,” while, in 2019, it was “*Complexity of Decisions and Decisions for Complexity*”. The choice of the term of the year (the subtitle) provides us to get access to the same castle through different routes and aspirations,

taking up a renewed methodological pluralism in the name of the consilience of knowledge. The term of this year is “*Minds, Machines and their Society*”.

In 1950, in the leading philosophy journal *Mind*, Alan M. Turing proposed his famous Turing Test, which indicates the possibility of artificial intelligence and mechanisation of the mind. The man or the machine behind the screen of the test becomes a septuagenarian this year. Therefore, we make our memory of this long-standing test be explicit by titling the book with both minds and machines. Machines have been long designed or invented to shed light on how minds work. In other words, if the mind is the philosophical inquiry, then the machine is applied to meet the epistemological deficit. In the philosophy of mind, the debates over the relations between minds and machines have never rested. We now have various speculations and implications. One anticipation is that machines will do whatever minds may accomplish. If that happens, what is the relation between machines and minds? Would machines replace minds and make minds be wasted lives (see, Bauman 2013). If this happens, where is humanity? Alternatively, machines may never be able to become minds; nevertheless, they can facilitate minds to work better as the pens and pencils had done for us a long while ago. In the later anticipation, machines are part of the society of men. Hence, a synthetic viewpoint suggests a united society of minds or machines, and this synthetic viewpoint, conventionally known as cyborgs, becomes the last part of the subtitle (for more on the concept of consilience, see Wilson 1998).

This book, based on the selected peer-review papers duly presented and widely discussed at DECON 2020, is structured into five main parts / themes, each of them representing at least one key aspect of Decision Economics. Part I, *Turing Test: Computable Humanities*, is inspired by the research work of Alan M. Turing (1912–1954) and is devoted to the 70th anniversary of his Turing’s Test (Turing 1950). This part begins with a promising essay by Daniela Cialfi, which is an interesting, novel formalisation of a decisional Turing Machine, followed by a study of intelligent machines and reverse Turing Test with regard to socio-economic decisions. Part II, *Minds: Cognitive, Behavioural, and Experimental Perspectives*—purports to provide decision procedures by means of cognitive approaches such as computer science, neuroscience, and behavioural and natural experimentation. Part III, *Machine Learning: Application and Analysis*, succeeds in handling a wide range of problems from financial ratios and financial time series to portfolio management via empirical asset pricing, from stacking generalisation to Bayesian dialysis and financial econometrics. Part IV, *Agent-Based Modelling and the Related*, is mainly concerned with research that simulates the pricing activities with different behavioural rules. The group also includes a study that focuses on individual and collective decision-making as well as a study on the knowledge complexity diffusion. In Part V, the last part, we have miscellaneous noteworthy topics related to decision making, ranging from modelling cost-benefit integration, informing a financial market, developing a data processing economy, and reviewing intertemporal choice methodologically.

Curtain Call: Honors, Tidbits, and Thanks

Now that this book has been successfully completed, we are in a much better position as we move into 2021, especially to make sense of what happened in the 2020 edition of DECON. On behalf of all of us who were involved in writing this book, or parts of it, we would like to express our sincere thanks to all our reviewers for taking their time—this year particularly—to rigorously read and evaluate the individual chapters as well as this Preface prior to publication and provide the editors and authors, too, with their generous endorsements. Moving beyond rhetoric, furthermore, our greatest debt of gratitude is owed to all the members of the International Program Committee and to each of the contributors in this volume. Among the latter, we are pleased to announce and celebrate the winners of the two international awards of “Decision Economics 2020”: Jan Treur, from Vrije Universiteit Amsterdam, Netherlands, is awarded for the *best paper* entitled “From Individual Decisions to Collective Decisions Changing the World”; and Juan Manuel Sánchez-Cartas, from Polytechnic University of Madrid, Spain, is awarded the *best application paper* entitled “Platform Competition and Consumer’s Decisions: An ABM Simulation of Pricing with Different Behavioral Rules”. Our congratulations go to them on achieving their well-deserved and internationally recognised awards. Further social events are being planned as this book goes to print. In particular, two other prizes are currently being awarded, namely, “*Research and Intellectual Social Responsibility*” and “*Early-stage Researcher Award*” both under the aegis of the United Nations. These two awards, however, require the in-person ceremony, thus we cannot disclose the names of the winners, in accordance with the protocol provided for the purpose by the United Nations Academic Impact.

We also like to take this opportunity to introduce Javier Parra Domínguez, who joins the Organising Committee this year. Parra Domínguez currently is an assistant professor at the department of business and economics administration, University of Salamanca. His research expertise is in financial economics and accounting. The three founding fathers of Decision Economics wish him all the best in this new assignment and thank him for taking up this challenge. Under the aegis of United Nations, DECON 2020 was organised by the University of Chieti-Pescara (Italy), the National Chengchi University, Taipei (Taiwan), and the University of Salamanca (Spain), and, given the evolution of the global pandemic circumstances, it was held virtually from 7th to 9th October, 2020, recording every single presentation, although it should have been originally hosted by the University of L’Aquila. All opinions expressed in the contributors’ chapters within this book are those of the authors and not of any organisation with which they may be associated. Last but not least, the editors are grateful to the sponsors: IEEE Systems Man and Cybernetics Society, Spain Section Chapter, and IEEE Spain Section (Technical Co-Sponsor), IBM, Indra, Viewnext, Global Exchange, and AEPIA-and-APPIA.

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October 2020

Edgardo Bucciarelli
Shu-Heng Chen
J. Manuel Corchado
Javier Parra D.

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Decision Economics Prize Awardees

2020

Best paper: “*From Individual Decisions to Collective Decisions Changing the World*” by Jan Treur (Vrije Universiteit Amsterdam, Netherlands).

Best paper application: “*Platform Competition and Consumer’s Decisions: An ABM Simulation of Pricing with Different Behavioral Rules*” by Juan Manuel Sánchez-Cartas (Polytechnic University of Madrid, Spain).

2019

Best paper: “*Calibrating Methods for Decision Making Under Uncertainty*” by Robert E. Marks (University of New South Wales, School of Economics, Sydney).

Best paper application: “*Coordination and Search for New Solutions: An Agent-based Study on the Tension in Boundary Systems*” by Friederike Wall (University of Klagenfurt, Department of Management Control and Strategic Management).

Organisation of the International Conference on Decision Economics 2020

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Founders of Decision Economics

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Juan Manuel Corchado	University of Salamanca, Spain

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