What is policy analytics? An exploration of 5 years of environmental management applications

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27

28   Abstract

29   Our digital age is characterized by both a generalized access to data and an increased call for

30   participation of the public and other stakeholders and communities in policy design and decision-

31   making. This context raises new challenges for political decision-makers and analysts in

32   providing these actors with new means and moral duties for decision support, including in the

33   area of environmental policy. The concept of "policy analytics" was introduced in 2013 as an

34   attempt to develop a framework, tools and methods to address these challenges. This conceptual

35   initiative prompted numerous research teams to develop empirical applications of this framework

36   and to reflect on their own decision-support practice at the science-policy interface in various

37   environmental domains around the world. During a workshop in Paris in 2018, participants

38   shared and discussed their experiences of these applications and practices. In this article we

39   present and analyze a set of applications to identify a series of key properties that underpin a

40   policy analytics approach, in order to provide the conceptual foundation for policy analytics to

41   address current policy design and decision-making challenges. The induced properties are

42   demand orientedness, performativity, normative transparency and data meaningfulness. We show

43   how these properties materialized through these six case-studies, and we explain why we

44   consider them key to effective policy analytics applications, particularly in environmental policy

45   design and decision making on environmental issues. This clarification of the policy analytics

46   concept eventually enables us to highlight research frontiers to further improve the concept.

47   Keywords: decision support; environmental policies; legitimacy; data; policy analytics

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49

50   1. Introduction

51   The digital age has provided access to multiple sources of data and information for an increasing

52   part of the world's population and has accelerated opportunities for their analysis, including

53   through increased computational capacity. At the same time, the demand for opening policy-

54   making processes to stakeholders, communities and the general public has evolved into a

55   generalized call for more inclusive and extensive participation, in some cases becoming

56   entrenched in national or supra-national regulations. This has often generated conflicting

57   understandings of problems, driven by multiple bodies of expertise and knowledge on the same

58   issues, which are embodied by diverse actors in society (see for example Arts et al. 2017). Since

59   the expansion of environmental movements in the 1970s and 1980s around conservation and

60 environmental protection, the environmental policy domain has long been a prominent arena for

61 the tension between these two trends (increased information availability and calls for

62 participation) (e.g. O'Donnell et al., 2019; Long, 2019). However, the current digital age has

63 rapidly exacerbated the availability of multiple, and at times contradictory, bodies of

64 information.

65 This context raises new challenges and opportunities for innovatively engaging citizens in

66 decision-making, and improving policy makers' capacities to intervene effectively in complex

67 problems. In recent years, Government actors have more actively sought to address both the

68 opportunities and challenges of new demands and capabilities driven by technological change, as

69 highlighted by the proliferation of various dedicated policy and legislative instruments, such as

70 the General Data Privacy Regulation (GDPR) in Europe, and high-level strategies developed by

71 the US, China, France, Germany, and Australia (e.g. DISS 2018, Federal Data Strategy 2019,

72 FMEAE 2018, The White House 2019, Villani 2018, Webster et al. 2019).

73 Parallel to, and in support of these shifts, academic research is also seeking to formalize new

74 models of decision support to environmental policies, to enable a productive interplay between

75 the use of new information technologies and the enhanced public participation. Among these

76 initiatives, policy analytics, as formalized in Tsoukias et al. (2013) and Daniell et al. (2015),

77 provides a framework, tools and methods fit for purpose. The term 'analytics', has historically

78 been used for decision support within individual sectors, with previous research focusing on

79 areas such as 'business analytics', 'health analytics' and 'learning analytics'. Across these

80 applications, the term 'analytics' is understood as an umbrella term describing a variety of

81 analytical methods and approaches with a sophistication that can match the complexity of the

82 data types (both qualitative and quantitative), processing and analysis demands of the digital age

83 (Tsoukias *et al.*, 2013). Tsoukias *et al.* (2013) wanted to promote the use of such 'analytics' tools

84 to address the public policy issues for which they may be relevant. However, Tsoukias *et al.*

85 (2013) also stressed the relative difficulty of applying 'analytics' within the public realm, mainly

86 due to the unique constraints associated with decision support of public policies; in particular,

87 the use of public money and the associated need for transparency, the prevalence of participatory

88 and deliberative processes, and the non-monetary and multifaceted nature of policy goals. To

89 capture this two-fold ambition, they defined "policy analytics" as a project to *"support policy*

90 *makers in a way that is meaningful (in a sense of being relevant and adding value to the*

91 *process), operational (in a sense of being practically feasible) and legitimating (in the sense of*

92 *ensuring transparency and accountability), [by drawing] on a wide range of existing data and*

93 *knowledge (including factual information, scientific knowledge, and expert knowledge in its*

94 *many forms) and [combining] this with a constructive approach to surfacing, modelling and*

95 *understanding the opinions, values and judgements of the range of relevant stakeholders".*

96 This concept of "policy analytics" has aroused interest among many researchers in the

97 environmental policy domain in recent years, with numerous discussions about its utility and

98 possible improvements, and several applications in the field being held in different places around

99 the world. This article aims to draw on these discussions and applications to clarify the policy

100 analytics concept so that its use and relevance can be clarified and expanded. To that end, we

101 analyze a series of examples of concrete applications of the policy analytics framework to

102 environmental policies. We first outline our methodological approach for clarifying the concept

103 (section 2). We then implement this approach (section 3). We present our series of case studies

104 (subsection 3.1). We then articulate four normative properties that emerged from the discussions

105 and comparisons of these case studies (subsection 3.2). These properties constitute the core of

106   our proposed improved definition of policy analytics. Lastly, section 4 outlines avenues for

107   future research on and around policy analytics.

108

109   2. A methodology to rethink "policy analytics" as an approach to support environmental

110   decision makers

111   In their context of launching a research dynamic, Tsoukias et al. (2013) proposed a deliberately

112   wide definition of policy analytics in order to encourage discussions with a diverse and inter-

113   disciplinary group of researchers, policy officials and data industry collaborators. This strategy

114   proved effective, and a series of research projects were launched and developed, as part of an

115   effort to develop and gain traction for the policy analytics concept and its application. However,

116   this type of approach, which uses a more general definition to avoid excluding useful

117   contributions, also has its limits, especially once the concept is mature enough to be compared

118   with alternative frameworks.

119   As it happens, numerous other frameworks also attempt to address the challenges associated with

120   developing public policy in a highly data driven age, including "policy informatics" (Johnston,

121   2015), "computational social sciences" (Lazer et al., 2009), "big data in public affairs" (Mergel

122   et al., 2016), and "utilization-focused" and "systemic evaluation" of public policies (Midley

123   2006; Boyd et al. 2007; Patton 2008). Shared amongst these various frameworks is the

124   acknowledgement that our current information, communication and technological environment is

125   undergoing rapid changes, and consequently there is both a need and an opportunity for public

126   policy to utilize the capabilities of changing information and communication technologies.

127   Furthermore, these approaches also agree on the issues that will emerge from increased usage of

128   data in both public and private settings, including questions around privacy, legitimacy, and

129   accountability, and the need for new regulatory approaches that mandate certain standards in

130   relation to these governance attributes.

131   As various research teams began to attempt real-world applications of the policy analytics

132   concept, the lack of specificity in the definition prompted discussions on the definition itself, and

133   on what made policy analytics unique from the alternative frameworks highlighted earlier.

134   Various papers have proposed alternative definitions based on proposed clarifications of one or

135   several of the criteria mentioned in Tsoukias et al. (2013). Jeanmougin et al. (2017) proposed to

136   formalize Tsoukias et al. (2013)'s definition, using policy analytics as an evaluation framework

137   applied to a conservation policy, by singling out four elementary criteria, associated with

138   concrete examples. As compared with Tsoukias et al. (2013), this formulation retains the

139   operationality and legitimacy criteria, but replaces the "meaningfulness" requirement, which they

140   considered to be too vague, by two criteria referring, respectively, to a "scientificity"

141   requirement and a requirement to bring in a demonstrable contribution. However, this

142   clarification focused on a specific usage of the policy analytics framework (as an evaluation tool)

143   and applied to a specific context (i.e. conservation policies). Jeanmougin et al. (2017) also

144   highlighted the difficulty substantiating the "legitimacy" requirement at the core of the policy

145   analytics framework. Meinard (2017) attempted to clarify this requirement by proposing an

146   open-ended list of legitimacy criteria, but here again this attempt was focused on the specific

147   context of conservation policies. Interestingly, some of the criteria proposed referred to the

148   scientific credentials of the policies whose legitimacy was being evaluated, highlighting that the

149   four criteria proposed by Jeanmougin et al. (2017) are not completely independent. Although this

150   interdependency between some of the criteria constituting the definition is not necessarily a fatal

151 flaw, a definition based on independent criteria would certainly be clearer. In the same vein,

152 Choulak et al. (2019) briefly discussed the vagueness of the operationality criterion.

153 The need to clarify the definition and the risks associated with too rigid definitions were

154 discussed in numerous internal seminars among researchers in the group, based on applications

155 of various versions of the framework based on a broader variety of policy issues, including the

156 above mentioned environmental issues but also public health problems (Richard et al. 2018) and

157 public management issues (Touret et al. 2019). In the wake of theoretical work clarifying the

158 difference between tools, methods and approaches in decision support theories and practices

159 (Meinard & Tsoukias 2019), these discussions pointed to the conclusion that policy analytics is

160 neither a field (such as, for example, policy analysis) nor a tool nor a methodology (such as, for

161 example, focus groups or other participatory tools), but rather an "approach" to decision support

162 intended for actors in public policy decision making. Following Meinard & Tsoukias (2019), we

163 use the term "approach" here to refer to "a way by which [an analyst] conducts a [decision

164 support] process". A given approach can be applied to different issues, which can belong to

165 different academic fields, and it can make use of a variety of methodologies, which can

166 themselves be used by different approaches. In this understanding, which is anchored in

167 Habermas's epistemological views (Habermas 1985, 1990), "approaches" are defined by

168 normative properties that specify key aspects of the way analysts should use available tools and

169 methods.

170 This view of policy analytics as an approach embodying normative properties opens avenues to

171 complement the top-down definitional approach used in these previous works by identifying,

172 through a bottom-up procedure, normative properties, to some extent shared by exemplary case

173 studies, which could be considered to provide an addition to the definition of policy analytics.

174 Because the case studies explored below were performed with policy analytics in mind, they can

175 be seen as partial but complementary attempts to clarify an underlying ambition shared by all the

176 researchers who decided to gather under the banner of "policy analytics".

177 In this dynamic, during a workshop in Paris in 2018, a series of examples of policy analytics

178 applications to environmental policies have been shared and discussed by participants. These

179 applications provided the empirical material to venture a formulation of key properties, in an

180 abductive approach (Peirce 1966). This formulation was then used in a reconstructive approach

181 to rationalize some key aspects of the applications. The results of this reconstruction are

182 presented in the next section.

183 We should emphasize at the outset that efforts to clarify the definition in this way are not

184 doomed to constrain the potential of the concept, as Tsoukias et al. (2013) feared. As long as the

185 definition remains open-ended and open to discussion and improvements, attempts to refine it

186 can usefully clarify the underlying ambitions of different policy analytics research programs and

187 provide directions for future investigations.

188

189   3. Conceptualizing policy analytics: lessons from 5 years of applications

190 Using the methodology delineated above, in the present section, we start by describing the 6 case

191 studies that were discussed in the 2018 workshop (3.1). The descriptions are all organized in the

192 same way: We start by explaining the context (what is the policy at issue, what are the processes

193 engaged) (1). We then explain the reasons why the researchers involved conceived of their works

194 as applications of the policy analytics concept. Because, as explained in previous section, the

195 original definition of policy analytics was quite open, these reasons were disparate and, very

196 often, focused on quite different interpretations of the concept (2). We then describe the data

197   produced and/or analyzed (3). We finish by summarizing the outcome of each policy analytics

198   application (4).

199   Following this description of the case studies, we articulate the four normative properties that

200   emerged from the discussions and comparisons of case studies, which we propose as candidates

201   to structure an improved definition of policy analytics (3.2).

202

203   3.1. Examples of applications

204   3.1.1. Case 1: Elaboration of a wetland prioritization platform

205   (1) The first case involved the elaboration of an operational wetland prioritization platform in

206   Bourgogne-France-Comté (Choulak et al. 2019) that would be seen as legitimate by its key

207   stakeholders. Wetlands are ecosystems whose functioning is largely determined by water,

208   such as swamps, alluvial forests, bogs, etc. These ecosystems are the target of numerous

209   conservation policies around the world, including the RAMSAR convention, and dedicated

210   legislation in France. Wetland prioritization is a crucial step in most action plans devoted to

211   conserving or restoring wetlands in line with these policies. It consists of using available

212   data on wetlands (e.g. ecological features, hydraulic functions) and the context (e.g.

213   urbanization dynamics, land use) to decide on which wetlands managers should prioritize. In

214   2017, the "wetland taskforce" ("Pôle Milieux Humides") of the Bourgogne-Franche-Comté

215   region (France)—a team within a non-profit environmental organization (Conservatoire

216   Espaces Naturels)—was entrusted to elaborate a spatialized database on wetlands by a

217   consortium of regional to national scale institutions funding environmental actions. It was to

218   focus on the whole regional scale based on a new prioritization methodology that would also

219   need to be elaborated.

220   (2) Relevant databases available for prioritizing wetlands are large and heterogeneous, and very

221   often standard practices tend to conflate very different kinds of data indiscriminately. Some

222   of the databases house quantitative scientific data such as the results of hydrological models

223   or data on the abundance of a given species. Others have political aspects and may include

224   different forms of qualitative and quantitative information, such as zoning maps produced

225   through political processes. Tsoukias et al. (2013) emphasized the importance of taking into

226   account the nature and design of data to provide relevant and legitimate decision support.

227   The researchers involved in this case study therefore saw standard practices in wetland

228   prioritization as an example domain in which policy analytics could make a difference, by

229   developing methods that give importance to the nature of the data they use and their design.

230   (3) The data used were the contents of the spatialized database elaborated by the wetland

231   taskforce, and all the metadata corresponding to the methodologies used to capture these

232   data, which we used to develop rules to aggregate parts of the information in the database

233   using a rule-based approach (Azibi & Vanderpooten 2002). An example of a rule in this

234   context was "if there is no indicator in the database testifying that a given wetland plays a

235   role in flood mitigation, then this wetland is assigned to the category "*No information in the*

236   *database suggesting that it is suitable, even poorly, to pursue this objective to conserve*

237   *wetlands performing a flood regulation function.*" A rule-based approach consists in

238   identifying a consistent set of such rules allowing information in the database to be

239   aggregated. To design these rules, we worked with representatives of wetland manager

240   groups, who collectively identified a series of management objectives that they deemed they

241   had political legitimacy to choose. We then used a rule-based aggregation method and MR-

242   Sort, a non-compensatory aggregation method (Leroy et al. 2011), to produce a framework

243   that the wetland taskforce will be able to use autonomously.

244 (4) The concrete outcome is a platform with which the wetland taskforce will be able to prioritize

245   wetlands for managers, in a legitimate and fine-tuned way, thereby fulfilling the promise to

246   add value and strengthen legitimacy by paying particular attention to the nature and design

247   of data. The increased legitimacy stems from the fact that, whereas standard practices in

248   wetland prioritization indiscriminately conflate technical choices (concerning, for example,

249   the reliability of this or that indicator) and political choices (for example, choices of

250   objectives to pursue), this platform makes a point not to preempt the latter (see Choulak et

251   al. 2019 for more details). The platform has been applied to several projects over the past

252   few months (Melanie Paris, personal communication), and regional-scale funding

253   institutions are interested in applying this new method at a larger scale. From a theoretical

254   point of view, our main contribution is the notion of "meta-decision analysis." This notion

255   stresses that, while researchers in decision sciences can provide decision support to decision

256   makers in some contexts, many other actors, such as consultants, experts, stakeholders, and

257   so on, can play the role of "decision support providers." Instead of providing decision

258   support to a particular decision maker facing a particular problem, a researcher involved in

259   "Meta-decision analysis" will strive to identify and help legitimate "decision support

260   providers" to help decision-makers (see Choulak et al. 2019, section 2). Meta decision

261   support is, in our view, a corollary of the emphasis on legitimacy championed by authors in

262   the policy analytics space.

263

264   3.1.2. Case 2: Facilitating dialogue over a marine pollution dispute

265   (1) The second case study relates to the "red mud" conflict in the Calanques National Park (South France). In Marseille, there is an enduring dispute about waste disposal in the Mediterranean Sea, which is supposedly forbidden by the Barcelona convention of 1992. A factory has had a long-term special dispensation allowing it to dispose of massive quantities of residuals of the transformation of bauxite—the so called "red mud". This pollution is considered illegitimate by a part of the population and creates a strong political conflict, although most people also acknowledge that the jobs provided by this factory are vital for the area. Despite public worries, the administration believes that all has been done to improve practices – but there is no communication among opposing worlds and thus no reduction of political conflict, and as a result the main argumentative discussions take place in judicial courts.

276   (2) In this context, the data available on past and current disputes are numerous (e.g. reports by experts and consultants, surveys by journalists, scientific studies, data from monitoring programs). However, in this deeply conflictual context, some of these data can be easily manipulated, and tracing back the biases that might have plagued them is hazardous. This is why the researcher involved in this case study saw it as an especially potent illustration of the idea, stressed in Tsoukias et al. (2013), that in such a complex context, sui generis processes are required to generate reliable data.

283   (3) A role-playing game was co-produced with local inhabitants, environmental associations, political decision makers and representatives of the factory to represent a range of points of view and values in a single format. Based on long interviews, cognitive maps that brought together definition of problems, actors, and possible actions were produced. Lastly, three participatory techniques were used to help structure debates: a serious game, participatory

288　theatre and the co-construction of a research project between researchers and activists. The

289　serious game initially aimed to create debate but was transformed into an education game

290　because the field study itself created too much tension. It has been used in diverse contexts in

291　the region since then, but never with a group of people in serious conflict. Artists then

292　developed a theater play to organize discussion forums where opponents to the factory,

293　involved scientists, and the general public met and generated new discussions about the

294　problem and the possibilities for solving it. Eventually 50 interested people were invited to

295　co-construct a new research project about the multiplicity of forms of pollution and their

296　circulation in the area, so as to raise awareness of the red mud issue and evaluate the

297　vulnerability of the territory.

298　(4) The outcomes of this case study confirm the fruitfulness of developing *sui generis* tools

299　generating entirely new data, in a context in which analyzing existing data would be

300　methodologically questionable. The continued adaptation of the choice of participatory

301　techniques and their implementation in this case helped to better understand the diversity of

302　points of view. Contradictory normative views concerning social priorities could be

303　characterized and discussed, which facilitated communication among opposing worlds. The

304　co-constructed knowledge production has strengthened links between scientists and

305　associations, who in parallel have found representatives able to interact regularly with the

306　administration. Public trust in the administration was thereby strengthened and the

307　administration renewed their interest in creating arenas of dialog. However, the political

308　problem lingers on.

309

310　　　　　　3.1.3. Case 3: Facilitating reflection on a collaborative water management network

311 (1) The third case focuses on the construction of collaborative environmental networks in the
312   Gironde estuary (New Aquitaine, South West France) (Boschet & Rambonilaza 2017). In
313   the context of the Water Framework Directive (WFD) and its implementation at the local
314   river basin scale, as well as the Birds and Habitat Directives (Natura 2000 sites), several
315   participatory mechanisms have been introduced. At the same time, local decision-makers
316   have expressed their wishes to orient the future development of the riparian municipalities
317   around the preservation and enhancement of natural and heritage resources, in an area that
318   has historically had vocation as an industrial port. The major challenges were the lack of
319   links between the two shores of the estuary, and a lack of visibility for the group of
320   stakeholders who deal with the environmental issues of the estuary.

321 (2) One of the most important ideas emphasized by Tsoukias et al. (2013) in their introductory
322   definition of policy analytics is that public policy contexts make it particularly difficult to
323   use the sophisticated techniques typically associated with so-called 'analytics.' This is due
324   to the fact that these sophisticated techniques are difficult for stakeholders and decision
325   makers to understand, whereas in public policy contexts, transparency, participation and
326   deliberation play a key role. The researchers involved in the present case study saw this
327   context as an opportunity to test if it is possible to meet both policy analytics ambitions, by
328   putting some sophisticated analytic techniques—in this case network analysis and statistical
329   models—to use to help actors understand their interactions and to coproduce new
330   interactions.

331 (3) The case study involved an ex-post analysis of the functioning of collaborative
332   environmental governance and the main factors explaining how collaboration relationships
333   form, and an assessment of the heterogeneity and representativeness of the stakeholders

involved, as recommended by WFD (Art. 14). Data collection used documentary sources to identify representatives of organizations and count their participation in four policy processes in the Gironde estuary (514 individuals representing 386 organizations). A two-mode network methodology and preliminary field survey was used to define the population of interest ("the actors who act"). Then a final survey of this population produced data covering their exchanges of information, expertise and resources, as well as the names of the people who are members of their network, who were themselves interviewed afterwards. The interviewees were asked to name the network members who are the most important in the estuary's environmental management, then in a second step to name their actual partners, leading them to distinguish their understanding of the whole network and their personal network of collaboration. The survey, which followed a snowball sample methodology, was halted when no new names were mentioned by the respondents. These questions were integrated into a broader interview grid, which highlighted the interviewees' perceptions of opportunities and barriers to working with potential partners. The use of data (the actors involved and their relationships) first provided the current state of the collaborative network: the actors and their links, their position in the network, and the diversity of exchanges (financial, informational, contractual, informal...). A second step, which used statistical models of networks, consisted of assessing the factors facilitating or enabling collaboration links. In particular, the distance between the actors was systematically analyzed. By "distance", we mean not only physical distance, but also institutional distance (the positioning of stakeholders in relation to the rules governing the management of environmental issues); organizational distance (the principles that dictate the involvement of stakeholders within participation devices); and finally statutory distance (the

357 specificity introduced by the roles devolved to the political and administrative apparatus via

358 the statutes of the actors, elected or bureaucrat). The outcome was a visualization of the

359 collaborative network.

360 (4) This work makes several contributions, illustrating how analytics tools can be put to use in a

361 public policy context, despite the prima facie contradiction between the complexity of these

362 tools and the requirements of participation. It provides a robust representation of the current

363 state of the group of actors involved and a factual proof of the separation between the two

364 shores in terms of collaboration, and cognitive support to the actors involved in terms of

365 their social working environment. It also helped the Gironde and Charente local

366 administration ("Conseils Départementaux"), and the "Syndicat Mixte" of the Gironde

367 Estuary, to rebuild the collaborative network of actors mobilized around environmental

368 stakes in the estuary. It is also a renewal of the political economy analysis of the

369 implementation of environmental policies at the local level. This work also forced some

370 actors to acknowledge the inertia of some networks of interaction, and its adverse

371 implications. This eventually enticed them to encourage the arrival of new entrants,

372 particularly economic players who have developed activities related to the estuary's heritage.

373

374 3.1.4. Case 4: Water management policy design

375 (1) This case study deals with water management in the agricultural system of the Apulia Region

376 (Italy), characterized by policy resistance that hampers the implementation of a water

377 protection policy. Due to the limited availability of water resources, the agricultural

378 activities are characterized by the combined use of both surface water and groundwater.

379 Groundwater overexploitation depletes water quantity and quality, leading to long term

380   social and environmental problems, including restrictive groundwater measures according to

381   the Water Framework Directive (Portoghese et al., 2013). The policies implemented in the

382   area aim either to improve the efficiency of groundwater use through innovative irrigation

383   techniques or to restrict groundwater use through policies and a tight control of Farmers'

384   activities (Giordano et al. 2015). Based on a traditional policy making approach, this policy

385   was developed without considering the potential impacts on the stakeholders, creating

386   strong conflict between stakeholders. This case study hence represents an emblematic

387   example of the complexity of water management, where decision-makers with competing

388   objectives and values need to share the same resource. A limited understanding of the

389   different problem framings can be a source of conflict, hampering the implementation of

390   and/or reducing the effectiveness of environmental policies (Giordano et al. 2017).

391   Stakeholders act as if the decision space was as simple as they presume it to be (i.e. ignoring

392   the role of some of the other actors and/or making assumptions about their decisional

393   processes). A detailed description of the case study and the analysis of the ambiguity in

394   problem framing can be found in Giordano et al. (2017) and Pluchinotta et al. 2018.

395 (2) By highlighting the distinctive challenges involved in trying to use 'analytics' tools in public

396   policy contexts, publications on policy analytics provide a partial explanation of the fact that

397   sophisticated decision support methods tend to be poorly used at least in some public policy

398   contexts. It occurred to the authors involved in this case study that their context of defective

399   water management policies illustrated this idea. They therefore took this context as an

400   opportunity to try to fulfil the corresponding promise of policy analytics, which is to put

401   state-of-the-art decision support tools to use in a complex and conflictual public policy

402   context.

(3) The data generating work focused on the policy design process (i.e. design of policy alternatives), using an innovative participatory approach. Mainstream policy tends to neglect the generation of novel policy alternatives and is more concerned with evaluating known alternatives (Ferretti et al. 2018, Pluchinotta et al. 2019). The experiences carried out in the Apulia case study supported the application of the Policy-KCP participatory tool for the design of policy alternatives, integrating Decision science and Design theory. Policy-KCP (P-KCP) is a Concept–Knowledge theory driven tool (i.e. one of the available design theories), adapted to the design of abstract objects such as public policies. The P-KCP aims to formalize the innovative design of policy alternatives within a public decision-making process. The P-KCP supports the creation of a shared artefact (Ostanello and Tsoukiàs 1993), further motivating stakeholders' engagement and commitment to a participative policy making process. The steps of the P-KCP participatory tool are described in Pluchinotta et al. (2019). The P-KCP participatory tool assisted policy makers and stakeholders to work together to the generate policy alternatives and overcome the difficulties of traditional approaches. The phase of knowledge elicitation and alignment (P–K phase) represents the starting point for building a shared concern, toward a generative phase (P–C phase). The P–K phase supported identification of the state of common knowledge on groundwater protection and surface water management problems, including the quali-quantitative state of aquifers and the analysis of the different stakeholders' problem framing (Giordano et al 2017). The knowledge elicitation activities were carried out by integrating scientific and technical pieces of evidence available in literature with expert and local knowledge according to participatory work principles. The results of semi-structured interviews structured in mental models were combined with the outputs of the

426   stakeholders' analysis and scientific literature studies, available data, emerging

427   technologies, best practices and current policies.

428   (4) The main outcome of this study was the pilot application of an original approach for the

429   innovative design of policy alternatives, illustrating how a state-of-the-art decision support

430   tool can be implemented in a complex and conflictual public policy setting. The proposed

431   methodology (P-KCP), integrating Decision Science and Design theory, formalized the

432   policy design process and supported the generation of previously unimaginable policy

433   alternatives. It connected local and expert knowledge within the whole design process

434   thanks to the construction of a collective problem understanding (i.e. a shared concern). It

435   brought together stakeholders, experts, institutional and non-institutional actors aiding them

436   to find new ways of working together efficiently, generating innovative possible alternatives

437   and encouraging longer term thinking. As a result, we observed that policy design can be a

438   generative process for the creation of a new dimension of values, through the creation of

439   new variables and/or the elimination of variables having little value for the process. For

440   example, within the case study, we were able to introduce new alternatives in order to

441   modify the value structures in a successful policy making.

442

443   3.1.5. Case 5: Decision support for catchment management

444   (1) This study deals with a collection of decision support processes involving modelling for

445   integrated catchment management and the stakeholders of these catchments, carried out by a

446   team of researchers at The Integrated Catchment Assessment and Management Centre

447   (iCAM) at the Australian National University over the past few decades (see Merritt et al.

448   (2017) for an overview of some applications). Integrated Water Resources Management is a

449   widely recognised paradigm for making more inclusive policy decisions regulating the

450   many, often competing, users of water; however, without effective decision support or

451   'policy analytics' the promise of the paradigm is hard to realise. Focusing on a typical

452   situation, a project is developed in partnership with water management authorities in

453   Australia through co-creation of a research topic, informed by both opportunities identified

454   by the university and available resources and priorities of the agency. To ensure legitimacy

455   of the decision-support processes and models, a steering committee is used to provide

456   feedback, in addition to having close involvement from government personnel and

457   landholders.

458 (2) While some of the collection of work in this case study pre-dates discussion of the

459   expression "policy analytics", the researchers involved consider the use of analytical tools to

460   support policy decision making eminently aligned with policy analytics, notably through the

461   use of participatory techniques combined with integrated modelling; the projects typically

462   satisfy all four normative principles defining policy analytics, as listed in the next section.

463 (3) A typical project merges data and information from stakeholders and science through

464   participatory processes and integrated modelling. Modelling provides a natural means for

465   organizing and integrating economic, ecological, hydrological data, qualitative stakeholder

466   input and interviews. An iterative process is adopted (Jakeman et al. 2006), recognising that

467   design of both participatory processes and integrated models needs to be purpose and

468   context-driven, but that new information arises over time that require changes to the project

469   plan (Lahtinen et al. 2017). Data used in the construction of models and that from their

470   resulting outputs play an important role in water management in understanding biophysical

471   processes and anticipating impact of policy or management measures. Integrated modelling

472   then helps to tie economic and ecological outcomes with hydrological processes and

473   intervention measures. Workshops to gain a common understanding of the system are

474   supplemented by interviews targeting sector-specific understanding of agriculture and

475   ecological outcomes. A pragmatic model building approach is used, involving representing

476   systems at the required level of complexity and mixing methods for different model

477   components in order to best integrate knowledge of decision makers, multiple expert

478   disciplines, and on-the-ground stakeholders. A spatially semi-distributed hydrological model

479   provides information at key points and aggregate regions, reducing the risk of information

480   overload for users, and allowing for interactive use of the model. Uncertainty in outcomes is

481   dealt with using scenarios and Bayesian Networks (Kelly et al. 2013; Maier et al. 2016),

482   which have typically received positive feedback from users. The result is inherently

483   interdisciplinary, such that communication within the project plays an important role.

484 (4) Project outcomes are delivered both through the stakeholder engagement process and

485   produced model and decision support tool. The stakeholder engagement process facilitates

486   social learning and shared problem framing, as well as building trust in the model. The

487   model provides cross-sectoral estimates of the impact of various water policies and

488   management interventions, in a transparent, traceable manner that the stakeholders can

489   critique and discuss. Both the engagement process and produced tool then influence

490   regulatory and agricultural decision making processes. Importantly, there is no ex ante

491   expectation that the model or outputs are directly *referenced* in decision making. The project

492   is understood to be one of many sources of information that decision makers draw on.

493   Shaping understanding of the situation is the main priority, along with adjusting different

494   stakeholders' views of how the world operates and their relationships to each other, which

495 makes evaluation of this type of policy analytics project particularly challenging (Hamilton

496 et al. 2019).

497

498   3.1.6. Case 6: participatory revision of a water management plan

499 (1) This study focuses on the participatory process used to revise a water management plan in

500 the Drôme river valley, located in southeastern France. The river is managed by a basin

501 institution and a local water committee. The basin institution is in charge of coordinating

502 stakeholders, facilitating the local water committee and carrying out construction and

503 maintenance work. The local water committee is in charge of developing, revising and

504 monitoring the implementation of the river management plan. The first river management

505 plan in the Drôme was established in the mid 90's (the Drôme was the first river basin in

506 France to establish a river management plan). This plan was revised for the first time

507 between 2007 and 2013. For the second revision, starting in 2018, policy-makers were

508 willing to use an innovative approach, by enabling citizens to make concrete proposals that

509 would then be examined by the local water committee for inclusion in the revised river

510 management plan. This participatory process was supported by a European project, SPARE

511 (Strategic Planning for Alpine River Ecosystems, co-financed by the European Union via

512 Interreg Alpine Space), and by international researchers. As a result, between November

513 2016 and October 2018, 344 citizens were involved in the: i) launching of the process, ii)

514 design of the process, iii) participatory diagnosis of the river basin, iv) identification of main

515 stakes of the river basin and proposing of actions and v) synthesis of the results. In total, 62

516 participatory events were organized over 2 years.

517   (2)   The researchers involved saw this context as an opportunity to explore an aspect of the

518   ambition heralded by policy analytics: how a large amount of data could be gathered and

519   analyzed in a participatory context, in such a way as to improve the decisions made by

520   policy makers by anchoring them in new data, while monitoring the involvement of

521   participants in the process.

522   (3)   The various steps of the process produced a large amount of data, including 85 initial

523   questionnaires about citizens' perceptions of the river and of participation, 630 contributions

524   to the citizen diagnosis, 189 propositions of actions, 3 action plans, 1 final report, 5 thematic

525   syntheses sent to the local water committee and answers to 78 questions asked by citizens.

526   In addition, the participatory process itself was monitored and evaluated to provide data

527   about: the composition of the participants' group, its representativeness, the retention level

528   of participants (whether participants stayed throughout the whole process or left part way

529   through), etc. Data were collected by researchers, facilitators and participants themselves. A

530   group of 16 citizen volunteers contributed to data framing and collection. Data analyses

531   were made by researchers and policy makers while the process was underway.

532   (4)   The project facilitated a better understanding of the opinions, values and judgements of

533   participants: for example, the 85 initial questionnaires provided data about citizens'

534   perceptions of the river and of participation (see results in Ferrand, Girard, & Hassenforder,

535   2018   and   http://www.alpine-space.eu/projects/spare/en/pilot-case-studies/drome/charts).

536   The participatory diagnosis outlined what participants liked or disliked in the river basin,

537   what they considered needed to be conserved or modified, what data they lacked and what

538   questions they had. The results were also used to support policy makers, at two levels. First,

539   data produced by participants fueled the revision of the water management plan. It

540   highlighted issues that were important to citizens and that had been to date left out by policy

541   makers, a number of which were subjective, such as the importance of the landscape, and

542   attachment to the territory. It also allowed an analysis of who was present during the process

543   and those who were absent. For instance, since the process attracted mainly people over 65

544   in its initial phases, an online participatory tool was set up for the action proposal phase so

545   that working people and parents could participate as well. As a result, 52 additional

546   participants contributed. Adapting the process in real time illustrated how data gathering and

547   analysis can be included in the participatory process, rather than being postponed to the end

548   the participatory phase. Following a similar adaptive logic, the analysis of the participants'

549   group composition also fueled the reflexivity of the group of participants who wondered

550   whether they were legitimate to make decisions about the river if they were not

551   representative of the population. Finally, the project strengthened the policy process in the

552   sense that all the data produced was proof-read by participants and then put online, thereby

553   improving the overall transparency of the policy-making process (results were presented

554   during participatory events and available online on a forum that was set up purposefully:

555   https://sites.google.com/site/dromenjeu/). As a result, newcomers could see what had been

556   produced by the group when they joined the process, and participants could promote and

557   share their productions.

558

559   3.2. Properties of applications of policy analytics

560   As detailed in section 2, discussions and reflections on the above case studies (and additional

561   ones which are not detailed here, such as Kana et al. 2014, Merritt et al. 2017 and Raboun et al.

562 2019), led to the collective identification of normative properties that, we claim, should

563 accompany applications of policy analytics. The case studies explored above do not specifically

564 embody all these properties since they were not designed with these properties in mind. Rather,

565 they were motivated by publications and discussions on policy analytics or by ideas that featured

566 prominently in such discussions. The properties in this section were thus identified *ex post* from

567 the collective analysis of these studies. Future works embodying our four normative properties

568 will demonstrate what we now consider to be important attributes for policy analytics

569 approaches. The first two properties are concerned with capturing the specific aspects of policy

570 analytics associated with its anchoring in decision analysis. The other two are meant to outline

571 policy analytics features associated with its application to public policies.

572 We do not claim that each one of these properties is entirely novel for public policy studies.

573 Many studies could rightfully claim that they satisfy one of these properties, and there might

574 even be applications which satisfy several of them. Our claim is that a study that satisfies them

575 all materializes the ambition underlying the policy analytics research program.

576

577 P1: Demand-orientedness. Our experiences in the different case studies above showed us that, in

578 most cases, the fact that our academic initiatives could easily respond to a demand voiced by

579 actors in the field was key to fulfill the ambition of co-producing solutions with decision makers.

580 In the various cases in which the project was directly and explicitly requested by an institution or

581 an actor (the wetland taskforce and, ultimately, the consortium of water related institutions in

582 case 3.1.1, the local regional administration in case 3.1.3, various water management authorities

583 in case 3.1.5, the basin institution in case 3.1.6), this strengthened the involvement of various

584 actors in the decision process, including of course the one issuing the request but with others as

585 well. In the other cases (3.1.2 and 3.1.4), although the project stemmed from an initially

586 academic questioning point of view, the fact that they were addressing problems that actors

587 deemed important played a key role, which was demonstrated by the fact that various actors

588 ultimately endorsed the questioning as their own. This suggests the importance of endorsing the

589 normative idea that the justification of, and motivation for, an application of policy analytics

590 should not be purely academic, and should be anchored in a real demand, voiced by actors,

591 groups or institutions in the field. This does not always mean that the demand should pre-exist

592 and be voiced by an actor or institution already enjoying a form of authority: it can be created as

593 the research project unfolds, which can take time. But in that case the created demand will

594 qualify as a demand properly speaking, and the study will qualify as demand-oriented, if and

595 only if there are actors or groups or institutions who end-up endorsing this demand and making

596 use of the approach and its outcomes. This theoretically disqualifies academic studies that do not

597 respond to an actual use case, even if they claim to respond to a generic "societal demand". We

598 note that there will be much useful academic work required that may be pre-cursory to being able

599 to apply policy analytics approaches in a demand-orientated manner, such as algorithm

600 development and other methodological developments; and that in such situations the distinctions

601 between good theory development and praxis in any application-focussed academic endeavor are

602 inherently fuzzy.

603

604 P2: Performativity. By promoting operationalisation and the importance of co-production, policy

605 analytics stresses that decision support interventions should not be purely academic, and should

606 rather feed concrete applications, leading to improvements of the situation they study. This idea

607 played a key role in all of our case studies: in case 3.1.1, the outcome was a new prioritization

608 tool that the decision aiding provider will use on a daily basis in its interactions with wetland

609 managers, which will inevitably lead to concrete changes in their conservation strategies and in

610 the concrete restoration actions they will implement. In case 3.1.2, the project deployment led to

611 the construction of an active debate arena, enabling discussions among concerned populations to

612 be reorganized. The analytical results in case 3.1.3 helped to guide future actions of decision-

613 makers in association with the actors of the collaborative network, leading to the emergence of a

614 new "policy trajectory". In case 3.1.4, the study designed new policy alternatives, which will be

615 included in and enrich existing policy making processes. In case 3.1.5, water managers in

616 numerous settings used the results of the modelling exercise to inform and make planning

617 decisions. In case 3.1.6, the intervention led to process adaptations as illustrated by the online

618 participatory tool set up for the action proposal phase. In all cases, this direct link with

619 applications played a key role in ensuring the relevance and operationality of the approach. This

620 suggests the following normative property: the aim of applications of policy analytics should not

621 simply be to describe or analyze states of affairs or processes; it should be to support actions

622 which will encourage improvements of these states of affairs and processes, ideally in new and

623 positive directions. This application-focused aspect is what we call "performativity". This

624 excludes purely descriptive approaches. However, it does not exclude integration of descriptive

625 sub-studies within a policy analytics project.

626

627 P3: Normative transparency. Our various case studies show that, when trying to fulfil particular

628 aspect of the initial policy analytics' ambition, we were all led to work out our own normative

629 assumptions and forced to clarify and display them. This involves amongst others: reflexively

630   identifying or choosing the role that analysts have in their interactions with decision-makers

631   (illustrated in particular in case 3.1.1); analyzing and improving existing decision aiding

632   structures (3.1.3); analyzing and modifying when needed the set of stakeholders, concerned

633   citizens, and various experts that are involved in the decision process (3.1.6); analyzing the

634   broader significance of the results of the study, and its chosen boundaries, to identify if and how

635   they can support more generalized conclusions (3.1.1, 3.1.3, 3.1.4, 3.1.5, 3.1.6). This

636   requirement was present from the start in case 3.1.1, since the data was specifically selected and

637   aggregated in such a way as to prevent any risk that some actors might think that the method

638   used preempted legitimate political or other value-laden choices. In case 3.1.2, normative

639   considerations did not take center stage at the beginning of the project, but because the first

640   results unveiled clashes of normative frameworks among the actors concerned, the need to be

641   transparent with respect to the normative underpinning of the methods used ended-up playing a

642   key role. In cases 3.1.3 to 3.1.6, the participatory aspects of the study similarly led to the

643   emergence of a diversity of value frames, which had to be taken into account on an equal

644   footing, thereby forcing our own interventions to be transparent with respect to their normative

645   anchorage. With the benefit of hindsight, this idea appears crucial, since it conditions our ability

646   to support decision makers in their own attempts to be transparent and accountable, in particular

647   in their interactions with decision support providers (be they researchers, consultants or in-house

648   policy analysts). This suggests the following normative property: applications of policy analytics

649   should clarify, display and account for their normative underpinnings, both in terms of the points

650   of view taken into account and in terms of how interactions between analysts, decision-makers

651   and stakeholders unfold. This property excludes, for example, welfarist economic, public

652   management approaches and others that do not make explicit their ethics and values-based

653   assumptions.

654

655   P4: Data meaningfulness. The term "analytics", in "policy analytics", was purposefully chosen to

656   emphasize that one of the most important (if not the most important) ambitions of policy

657   analytics is to reinforce the importance of reflecting on the nature and meaning of data used to

658   support policies. The general availability of numerous and sometimes large datasets that

659   characterizes our digital age means that large quantities of data can be easily accessed and

660   computed. But information on the context that has led to the emergence of these data, the

661   protocols used, their intrinsic limits, the paradigms that should accompany their interpretation;

662   rather than being forgotten in this process. Devictor & Bensaude-Vincent (2016) and Jaric et al.

663   (2019) provide detailed examples of the problems that this can create for environmental policies,

664   as data are computed and interpreted in questionable ways. Several of our case studies were

665   motivated by attempts to master the whole process of data generation and analysis needed to

666   overcome such problems. In case 3.1.1, data were specifically selected and aggregated in

667   different ways depending on how stakeholders understand them. The choice of aggregation

668   methods was then dictated by the interpretation of the data shared among acknowledged experts,

669   and known or suspected associated uncertainties and knowledge-gaps, which involved avoiding

670   commonly used, more mechanistic weighted-sum methods which silence these features of data.

671   In case 3.1.2, the methods used guided the data collection rather than the other way around. In

672   case 3.1.3, the data were constructed with the actors with a continuing attention to how various

673   actors or groups understood them. In case 3.1.4, the Policy-KCP participatory tool (Pluchinotta

674   et al. 2019, Giordano et al. 2020) assisted collaboration between policy makers and stakeholders,

675   connecting local and expert knowledge within the whole design process thanks to the

676   construction of a collective problem understanding (i.e. a shared concern). Similarly, in cases

677   3.1.5 and 3.1.6, participants were encouraged to contribute to data framing and collection (P3).

678   In all the cases, the data meaningfulness issue hence appears crucial, and the *ex post* analysis

679   even suggests that it could have played a more central role. This is why we champion the

680   following normative property: the analysis of the nature and meaning of data, determined by

681   their context of emergence, protocols used, intrinsic uncertainties and limits, and associated

682   paradigm, should all play a key role in any application of policy analytics. Notice that this

683   requirement does not prevent including, and even advocating for, gathering experience on the go,

684   for example through using real-time sensor feeds or logbooks. These tools are meaningful for

685   both reflexive ex post analysis and formative tracking of system impacts, providing some

686   immediate reflexivity or 'feedback' to be used in the policy process itself, for example to identify

687   a particular threshold that may be crossed.

688

689   The four properties articulated here can thus be seen to provide a concrete shape to the promise

690   of policy analytics approaches, including to allow them to tackle a number of challenges

691   associated with digital age and participation, as spelled out in the introduction. Data

692   meaningfulness (P4) aims to reduce the risk of policy makers feeling overwhelmed by data,

693   whose analysis can end-up being entirely beyond their control, as well as to allow them to

694   benefit from messy or unstructured data produced through participatory processes. Normative

695   transparency (P3) can similarly be seen as a safeguard to prevent decision processes from being

696   captured by blackbox models and policy processes that obfuscate the actors and their stakes or

697   interests in them. These two properties can be seen as two constraints on decision support

698   activities that, in what might seem to be paradox at first glance, are at the same time all the more

699   important and all the more difficult to abide by in the digital age. The importance and difficulty

700   of the challenge justifies the need for not just incremental improvements in policy analytics

701   practice, but also major, disruptive innovations in policy making. These can only be delivered by

702   ambitious research activities rethinking the very structure of decision support science and

703   practice. This is epitomized again by the emphasis on learning in P3 (normative transparency),

704   while emphasizing that the innovations produced should have impacts in real life (P2,

705   performativity) and fulfill real needs or demands rather than emerging from purely theoretical

706   whims (P1, demand-orientedness).

707   Based on this analysis, we claim that these four normative properties should be understood as a

708   definition for a *bone fide* application of policy analytics. Our case studies were not elaborated

709   with these four normative properties in mind. Rather, as explained in our methodology, they

710   were elaborated with the ambition articulated by policy analytics in mind. Specifically, the

711   properties were ventured *ex post*, through a structured collaboration process of discussion and

712   case study analysis, so as to strengthen applications of policy analytics in the future. The six case

713   studies therefore do not all materialize the four properties to the same degree. The four

714   properties, however, arguably account for important aspects of all six case studies, and point to

715   areas where each could have been ideally improved to lead to greater policy impact.

716

717   4. Agenda for further policy analytics research

718   As the above account illustrates, we conceive of the development of policy analytics as a

719   dynamic project. It was launched as a conceptual contribution, but its contours are being refined

720   as more and more practical applications have been uncovered from past practice, recently

721 implemented with the policy analytics concept in mind, and subsequently stimulated reflection

722 and prompted adjustments to both policy analytics theory and praxis. This article attempted to

723 capture the core ideas and motivations underlying recent applications and developments of the

724 concept. However, the resulting picture should not be seen as a final description, but rather as a

725 step in a continuing dynamic, whereby we hope to further improve the framework in the years to

726 come through new applications to what we see as emergent, challenging and pressing issues. In

727 this final section, we would like to emphasize a handful of the major issues which could structure

728 a useful research agenda for the policy analytics community in the near future to support it to

729 achieve its ambitions. The connection of each research frontier to the properties spelled out

730 above (P1-4) is also briefly discussed.

731 Our examples above highlighted the importance of participatory approaches in demand-

732 orientedness (P1). Accordingly, fully implementing this property raised challenges pertaining to

733 stakeholder selection issues, which have been an important research topic for a long time for

734 researchers concerned with engineering participatory processes and participation in policy

735 decisions (e.g. Daniell, 2012; Nabatchi, 2016). The works developed by policy analytics

736 researchers allowed important advances in the design of participatory processes and continuous

737 diffusion of data and information through these processes so as to ensure transparency,

738 relevance, and informed decision-making. However, as the process unfolds, the boundaries of the

739 issues tackled and problem formulations can evolve. Due to this evolution, the group of

740 stakeholders initially selected can become incomplete or partly irrelevant at a given stage of a

741 policy-support process. Similarly, a choice made initially concerning the process design, e.g. the

742 participatory methods selected or the roles assigned to some participants, may no longer be

743 relevant later given this evolution. There is therefore a need to identify technologies or

744   procedures to (1) facilitate co-evolution of the participants involved and of the process design,

745   while (2) keeping a memory of previous dialogues, achievements and evolutions. This is a major

746   research frontier for which policy analytics' distinctive interest in data analysis and meaning-

747   giving provide value through collection and use of data generated throughout these participatory

748   processes.

749   We have also seen above that participatory aspects of policy analytics projects play an important

750   role in fulfilling the requirements associated with data meaningfulness (P4). Accordingly,

751   another research frontier for the design of participatory processes is to elaborate means of

752   identifying the data and information that the various participants need to meaningfully participate

753   in the decision. Thinking more fundamentally about the notion of data, how data are created,

754   modified, circulated and re-used out of initially designed contexts is also an important challenge,

755   echoing the importance that policy analytics grants to data meaningfulness (P4). This reflection

756   also has aspects concerning data sovereignty and ownership, and what this means for policy

757   analytics under different jurisdictions. Particularly, policy analytics could integrate reflections

758   about issues of power linked to ownership and diffusion of data, or lack thereof. There are also

759   links to issues of data privacy and accessing environmental-related data about people, and how

760   the use of this should be managed. Likewise the challenges of what streams of data can be

761   meaningfully and ethically integrated to provide full (but perhaps too full) a picture of people,

762   their values, interests and preferences is highly topical as governments and corporations look at

763   their data assets and their perceived underuse (e.g. Löfgren and Webster, 2020). More generally

764   speaking on the area of participation linked to policy analytics, and already reported in the

765   literature (Mazri et al. 2019, Daniell et al., 2010), the design of participation structures is itself a

766   topic of participation, requiring design methodologies where participation is pragmatically

767 considered. Data, when used within complex and long decision processes, are generally subject

768 to several manipulation processes. Assuring the quality and meaningfulness of the entire data

769 pipeline is today a major challenge for the whole area of data science (Christophides et al. 2019).

770 An additional critical issue concerning the policy analytics topic is how to introduce innovation

771 within public policies, for example to conceive of currently inconceivable policies. The most

772 promising ideas come from joining analytics with formal design tools, allowing the emergence of

773 "out of the box" designs (Howlett, 2011; Pluchinotta et al. 2019), and in some cases a healthy

774 dose of considering science fiction and the cutting edge of artistic inspiration as an options set

775 worthy of formal investigation (Johnson, 2011; Wenger et al., 2020).

776 Important research frontiers also concern how to implement normative transparency (P3) in a

777 formalized, rigorous fashion. In this area, formal argumentation theory in artificial intelligence

778 (Rahwan & Simari 2009) holds important promise to help improve discussions around policy

779 analytics interventions. However, the possibility to use these approaches in this setting raises

780 important epistemological and methodological questions that they do not yet tackle. In particular,

781 if these approaches are used in real-life collective decision processes, they will have to answer

782 questions such as: who has the legitimacy to decide which arguments should be seen as good

783 arguments, and which ones should be considered spurious, and how transparency can be

784 guaranteed in argumentation processes? Cailloux & Meinard (2019) proposed a preliminary

785 formulation of a framework designed to overcome this (and other) limitation of such approaches.

786 Important challenges also lie in a proper integration of such tools in the proceedings of

787 discussions among people or groups, and the reflection of individuals involved, which remain the

788 core of what normative transparency refers to.

789   An associated issue, having to do with next generation algorithms (e.g. AI), is related to what

790   metrics are considered relevant when used as part of policy analytics. For example, perhaps

791   explicability of analytical processes and models is less relevant than legibility (Scott, 1998) and

792   trust. This is particularly important in automated/autonomous systems where decision and policy

793   makers may need to understand the different algorithms, data streams and sensors, and hence

794   trust each layer in the supply chain. What would useful policy analytics look like in such

795   systems?

796   Lastly, a major concern for future research that has to do with performativity (P2), is the long

797   term sustainability of the policy analytics interventions. Policy analytics activities should

798   arguably have long term benefits and co-benefits. Hence a future research avenue is to identify

799   what makes policy analytics approaches more salient for long-term policy support and

800   interventions in a variety of contexts.

801   Our six case study examples illustrate how the notion of policy analytics, in its original

802   conceptualization, proved useful to explore important environmental issues and support

803   environmental decision-makers for important decisions in the field. However, this agenda for

804   future research in turn shows how developing the concept in a bottom-up approach, far from

805   closing debates with a final definition, can help to structure future studies and open new research

806   avenues to further strengthen environmental decision support and the application of policy

807   analytics approaches more broadly.

808

809   Acknowledgements

813

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