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C-K$^{E/I}$: A pragmatic framework for policy innovation

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ABSTRACT

Improving policy making is key to address numerous contemporary challenges such as the environmental crisis, climate change, global inequality, financial crises, or pandemics. Policy making is a sequence of stages structuring policy problems and choices made to address them. Among these stages, policy design is a crucial phase since it impacts the quality of the policy alternatives being considered. Policy design is, however, largely neglected in the scientific literature, and in practice it is mainly conducted informally. Design theory, and more specifically Concept-Knowledge (C-K) theory, originally aimed at assisting the process of creating marketable objects, offers promises to formalize and rationalize policy design. We critically analyze this theory, showing that, despite its strengths, as it stands it is ill-adapted to support the innovative design of policy alternatives. For that purpose, we propose a framework, C-K$^{E/I}$. This framework, which is inspired by and compatible with C-K, appraises innovation based on the explicit or implicit modal statements held by a certain individual or group ("E/I" stands for Explicit vs. Implicit). Through an ex-post analysis of a case study—the search for innovative policy solutions to water management problems in the Apulia Region, Italy—we illustrate the practical applicability and usefulness of our framework.

1. Introduction

Policy making faces numerous problems in many regions of the world, due to the disparity of interests associated with the management of commons, the presence of multiple (and often antagonistic) decision-makers, the role of complex networks of formal and informal interactions, and also bureaucratic protocols, often-inoperative systems of governance, various socio-political events and environmental stressors such as climate change and unexpected pandemics (e.g., Moore et al., 2014).

Studying and eventually improving policy making is accordingly considered a major issue of public concern worldwide. Policy making is a public decision-making process (De Marchi, Lucertini, and Tsoukiàs, 2016) for defining sets of actions taken by a government to control a given system, to help solve problems within it, or to obtain benefits from it (Moran et al., 2006). It influences the life of stakeholders (e.g. Cochran 1995, Peters 1999), since it "decides who gets what, when and how" (Lasswell, 1936).

Policy making is classically conceptualized as a sequence of stages structuring policy problems and their resolution through choices made by policy makers (Daniell et al., 2016). Lasswell's classical presentation (1956) formalizes policy making as an ideal and continuous process, cycling through discrete activities producing policy outputs: issue identification, policy objectives definition, policy design, policy testing, policy refinement, policy implementation, policy monitoring and evaluation, and policy readjustment (this is the so-called "policy cycle"). Different authors used slightly different interpretations of the names, number and order of the stages, but retained the basic staged-feedback-cycle structure (e.g., Anderson, 1975; Dunn, 1994; Hill, 1997; Howlett et al., 2015; Jann and Wegrich, 2007).

For policy improvement purposes, policy design (the third of Lasswell's phases) is a crucial phase, since it influences the quality of the policy alternatives subsequently considered (Howlett, 2011). Therefore, policy design or "the invention of policy proposals" (Lasswell, 1956) is essential for the development of policy (Bobrow, 2006). Fostering innovation in policy design is accordingly a key challenge for policy improvement purposes (for details on the importance of policy design, see Ferretti et al., 2019).

The role of policy innovation in policy success or failure has long been debated (Grant, W., 2009; Polsby, 1984). As discussed by Howlett (2014), early studies focused on the cognitive limits of policy-makers and their bounded rationality as factors biasing decision-making towards known alternatives (Simon, 1955), or emphasized the complexity of decision-making processes involving competing interests (Lindblom, 1959; Simon, 1955). Other studies pointed to more structural factors such as routinization or institutionalization acting as a brake on innovation by restricting or constraining consideration of novel

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alternatives (Clemens and Cook, 1999). Scholars still discuss whether lack of innovation necessarily leads to overall policy failure, or if such outcome is rather amenable to failed policy innovations (Howlett, 2014 , 2015). These debates show that innovativeness is not sufficient to ensure the quality of policies: some innovative policies can be ill-conceived, and once innovations are at hand, choosing among them is an important challenge on its own. However, all other things held equal, innovation is a positive input to strengthen policy making, since designing a valuable new policy alternative can be worth more than a rehearsal of unsatisfactory standard alternative (e.g. Enthoven, 1975; Ferretti et al., 2019).

Despite the obvious importance of policy design in general, and of innovation in policy design more specifically, their analysis only belatedly became an important theme in contemporary policy research (Pluchinotta et al., 2020). Theorization has been lagging, the cumulative impact of empirical studies has not been great and understanding of the phenomena, despite many observations of its significance in policy studies, has not improved significantly (Howlett et al., 2015). In line with this lack of theorization, in practice policy design is typically done, rather informally, through the application of available knowledge to the development of actions expected to attain desired goals (Howlett and Lejano, 2013). The knowledge base used in this process is built on experience and reason, but not formally analyzed through a dedicated scientific apparatus (Alexander, 1982; Bobrow, 2006; Pluchinotta et al., 2019; Taeihagh, 2017). The very question of what should count as "innovative" in policy design matters is not even clarified in the literature.

This article aims to bring our contribution to fill this gap by conceptualizing a notion of policy design innovation and by helping rationalize this activity. Our approach to addressing this question does not consist in deploying a purely empirical protocol based on observing or asking a panel of respondents what they think is innovative within a policy design intervention. We rather propose a hybrid methodology combining conceptual and empirical analyses, in line with similar studies of other concepts playing a key role in decision-making processes, such as legitimacy (Meinard, 2017), justification (Meinard and Cailloux, 2020) and rationality (Meinard and Tsoukiàs, 2019). This hybrid methodology starts by analyzing relevant sources conceptualizing the notion of interest (innovation, in our case), through the lenses of conceptual analysis (Searle 1997), to propose conceptual refinements and then identify the empirical data and methodology that are relevant to test these findings. Future studies are then called for to develop full-fledged empirical validation, which would be premature at our stage in this article. This hybrid methodology is relevant for our purposes because, just like the other key notions listed above, innovation is both an ordinary language term and a highly complex notion used in various academic disciplines. In such cases, conceptual investigations are needed to structure associated empirical investigations since, for lack of such conceptual preliminary investigations, misunderstandings between respondents and investigators about the focal concept studied (here, "innovation") can lead to biased or misleading results.

As application of our hybrid methodology, the first step is to identify a relevant corpus of sources conceptualizing innovation. This is a challenge in its own right, since this notion is involved in an immense literature, spanning from late medieval philosophical reflections on political order (Pocock 2003) to contemporary design theory as applied to marketable objects (Le Masson et al., 2017). We do not have the unreasonable ambition to explore the entirety of these possibly relevant sources. We rather focus on one of the most prolific and prominent conceptual approaches to innovation in contemporary design, Concept-Knowledge (C-K) theory. This choice is motivated by the fact that, in addition to its academic prominence and widespread industrial and commercial applications, this theory arguably holds promises in the domain of policy design (Pluchinotta et al., 2020; Pluchinotta et al., 2019). Indeed, the latter studies showed that, within multi stakeholder policy contexts, C-K (i) helped formalizing the policy design process, supporting the generation of unimaginable alternatives thanks to the co-evolution of the K- and C-spaces according to the C–K framework; (ii) brought together experts, and institutional and noninstitutional actors aiding them to find new ways of working together thanks to the construction of a collective problem understanding; (iii) helped overcoming the dichotomy between expert and nonexpert knowledge and creating different knowledge subsets of the K-space in a more inclusive participatory process; (iv) supported the overtaking of the fixation phenomena through the creation of new concepts and facilitated the group learning process through the K- and C-space co-evolution. These four points strongly support the choice of C-K as a relevant corpus of theory and practice to be used to structure an investigation into (1) how policy design innovation can be conceptualized and (2) how the activity that consists in fostering policy design innovation can be rationalized. Based on this choice, we explore C-K theory at a theoretical level and show that, as it stands, this theory should be complemented by a framework, inspired by and compatible with it, but more specifically designed to support the innovative design of policy alternatives (Section 2). We introduce such a framework, C-$K^{E/I}$, appraising innovation based on the explicit or implicit modal statements held by a certain individual or group ("E/I" stands for Explicit vs. Implicit) (Section 3). This framework does not aim to replace or transform C-K theory from within. Our point is to propose a new framework, inspired by the literature on C-K theory, but specifically designed to be applicable to policy design. As application of the above-sketched methodology, these conceptual findings allow clarifying how empirical data can be collected and analyzed to test the practical relevance of this framework, which we do through an ex-post analysis of a case study, namely water management policy in the Apulia Region (Italy) (Section 4). Concluding remarks are reported in Section 5.

2. C-K theory and policy innovation

The current section will briefly present C-K theory (for more details, an interested reader should refer to Agogué and Kazakçi, 2014; Hatchuel et al., 2015; Hatchuel et al., 2013) and show that, though relevant to innovation in policy design, it deserves to be complemented to strengthen its possible applications to this domain. Design theory, originally conceived for assisting practitioners in "designing" marketable objects, has evolved in a more formal version aiming to assist and organize any process of creating "objects", possibly immaterial and abstract such as a strategy or a policy (Le Masson et al., 2017). These "objects" do not exist within our knowledge, but can be designed out of it (Hatchuel and Weil, 2003). In this regard, C-K theory offers a formal framework, which has been used to support the innovative generation of policy alternatives (see Pluchinotta et al., 2019).

According to its original definition provided by Hatchuel & Weil (2003), C-K theory is based on the distinction between two expandable spaces: a space of concepts (C-space), and a space of knowledge (K-space). K-space represents all the knowledge available to a designer (or to a group of designers) at a given time and contains all the established propositions (true or false), whereas C-space contains concepts, sets of propositions whose truth-value is unknown at the moment of their creation. Concepts are said to be undecidable propositions in K-space about partially unknown objects (Hatchuel and Weil, 2003). A proposition qualifies as "undecidable" relative to the content of a K-space if it is not possible to prove that this proposition is true or false in it. Concepts take the form: "There exists some object X, for which a group of properties p_1, p_2, …, p_n are true in K" (Hendriks and Kazakçi, 2010).

The design process is thus defined as the co-evolution of C-space and K-space (Hatchuel and Weil, 2009). In other words, design projects aim to transform undecidable propositions into true propositions in K-space. Hatchuel & Weil (2009) highlight the importance of the expandible K- and C-spaces as a unique way of capturing novelty, including a key feature of innovative design: namely, the revision of the identity of objects and the possibility of C-space partitions. As described in Hatchuel et al. (2017), there are two types of refinements in the C-space:

(i) expanding partition, when the partition expands the definition of an object with a new property that is not known in K as a possible property of this object; (ii) restricting partition, when the partition relies on an existing definition or property of the object in K. According to C-K theory, innovation is thus triggered by one or more expanding partitions and the knowledge used to form these partitions could have been present at the beginning of the process (existing one) or generated during the process (new one) (e.g., Hatchuel et al., 2017, Hatchuel and Weil, 2003). Therefore, innovation can also combine old pieces of knowledge, creating an artifact that goes beyond all combinations of the known pieces by "breaking the rules" (Hatchuel et al., 2018).

C-K theory claims that an innovative design process begins with an initial concept C_0 having properties true in a certain version of the K-space. Afterwards, a novel property is added to C_0 to form a new Concept C_1. Then the elaboration of concepts can be continued either by further C-space expansions or restrictions, i.e., by adding/removing properties of the initial concept C_0. When elaborating a C-space, a designer might use her/his K-space, either to partition further the concepts, or to attempt a validation of a given concept. This last type of operation is called K-validation and it corresponds to the evaluation of a design description using the K-space. The result of a K-validation is positive, if the designer determines that the proposition "there exist an object *X* with properties $p_1, p_2,\ldots, p_n$" is true. The result is negative, if the knowledge available to the designer leads her/him to state that the proposition is false (Hendriks and Kazakçi, 2011). In order to validate concepts, new knowledge warranting the existence conditions of such an object should be acquired: this is K-space expansion.

C-K theory, in this classical formulation, assumes that the notions of "object" and its "existence" are unproblematic. Based on these assumptions, the K-space is defined as the set of propositions known to be true about an object, and the C-space as the set of currently undecidable propositions concerning the object. This formulation is problematic because it tends to neglect an important distinction: the one between propositions for which it is meaningful to ask if they are known to be true or false, and those for which it does not make sense to ask this question. Notice the difference between being able to tell if a given proposition is true or false, on the one hand, and being able to make sense of the question whether this proposition is true or false, on the other hand. Hatchuel & Weil (2009) use as an example of a concept the following proposition C_0: "There is an Mg-CO_2 engine that is more suitable to Mars missions than classic engines". This illustrates the two ideas above. It makes sense to ask if this proposition is true or false only if we are able to tell what a Mg-CO_2 engine is, which, in fact, might be unclear when we try to design a Mg-CO_2 engine. Hatchuel and Weil (2009) write "there was no proposition within existing K that proved that C_0 was true or false. Thus, C_0 was a suitable concept for further design." In fact, if what "an Mg-CO_2 engine" refers to is too indeterminate, the question whether C_0 is true or false does not even make sense, and the question whether a proposition in K might prove that C_0 is true or false does not make sense either. As our formulation points out through the usage of the adverb "too", there is a continuum between, on the one hand, cases in which the "object" of interest is so indeterminate that the question whether the corresponding proposition is true or false does not make sense and, on the other hand, cases in which it is determinate enough to ask if the proposition is true or false. However, the fact that there is a continuum between these two kinds of cases does not mean that the difference between them is unimportant. Since current C-K theory literature neither points at this difference nor explores its implications for innovation, it tends to limit the analysis of innovation to a matter of changes in knowledge about objects that are clearly known from the beginning of the design process. In this view, admitting that we unquestionably know what *X* is, innovation appears when the evolution of knowledge entails changes in propositions that are known to be true or false about *X*. This vision downplays the specificities of what happens when it is unclear what *X* is, which is however very often the case when one sets out to innovate in designing *X*.

C-K theory says that what happens in the design process is that, at each stage i, a new proposition C_i has been formed: "There exists *X* with a set of attributes A_i, which can be made with a set of design parameters D_i". There are three possibilities for the logical status of C_i in K:

1 C_i is false in K and the design process has to change some of the A_is or the D_is;
2 C_i is true in K and (D_i, A_i) is one candidate as a "solution" for *X*; we call it a "conjunction for *X*";
3 C_i is neither true nor false in K, or it is not sufficiently described to attribute a truth-value to it: hence it is a new concept, and we have to continue the design process.

This can become ambiguous when it is not possible to know what *X* means precisely, in particular when relevant knowledge is scarce. Take the example of a chair (this is a classic example of C-K theory mentioned in most courses) and assume that A_i is the attribute "being two-legged". If knowledge about chairs is so scarce that the notion of a chair is not completely transparent, then it does not even make sense to ask if C_i is true, false or neither. If there were such a thing as an ultimate definition of what it means for an object to be a chair, it would make sense to ask if a two-legged object harboring A_i can be a chair. Our answer to this question might then change as knowledge evolves. However, because there is no such a thing as an ultimate definition of what a chair is, thinking about a two-legged chair is a thought experiment that can lead us to acknowledge that the idea of a chair is much less clear than one might think at first sight. Hatchuel & Weil (2009) are ambiguous when they talk about "new objects" or changing "identities of objects": on the one hand, they claim that objects change if the properties recognized to be attached to them change but, on the other hand, they assume that *X* is defined independently. This issue of the definition of objects becomes all the more important when innovation no longer is about "objects" in the everyday sense of the term, such as chairs or engines, but about policies. What does "*X*" stand for when we talk about a policy? To strengthen applications to policy design of the vision of innovation epitomized by C-K theory, there is hence a need to develop a framework accounting more satisfactory for what relevant "objects" are, and for people's ability to make statements as to whether propositions concerning "objects" are true or false.

3. C-K$^{E/I}$: a C-K-inspired framework dedicated to innovation in policy design

Although C-K theory assesses innovativeness with respect to the available knowledge at a given moment, in a given situation, and relative to a given available knowledge, it talks about innovation or innovative design in general, as if something could be innovative, absolutely speaking. However, some people can find a given item innovative while other people will find it blatantly run-of-the-mill. Taking this relativity of innovativeness assessment into account is not an important objective for the current C-K theory literature. By contrast, divergences in point of view play a key role in policy making (**Giordano et al., 2016**; **Pluchinotta et al., 2021**). A C-K-inspired framework designed to be specifically adapted to policy making should therefore pay much more attention to this issue. A first pillar for such a framework should hence consist in considering innovativeness as a property that is assigned by an individual or a group to an item. Typically, different people will find different items innovative. Within a group, if there is enough homogeneity among members, they can all agree on what is innovative and what is not. In practice, this kind of homogeneity can be empirically observed among groups of consumers with similar socioeconomic characteristics (at least in some cases and for some categories of consumable items whose innovativeness is of interest), or it can be generated by the co-construction of a shared understanding of an issue and a common knowledge background on it. Nevertheless, most of the time people will disagree, at least to some extent, on what is innovative and what is not, and aggregation mechanisms will be needed to decide what, if anything,

should be called innovative at the scale of the group. For our purposes in this article, we will leave this aggregation issue aside. We will talk about what is innovative for a focal individual *i*, granting that what we will say will be translatable into what is innovative for a sufficiently homogeneous group G, but can raise aggregation issues as soon as the group is heterogeneous enough for people to disagree within the group. It is worth underlining that there is no contradiction between, on the one hand, our claim that, in order to answer the question whether *x* is innovative for *y*, we need to focus on a homogeneous *y*, and, on the other hand, the largely demonstrated fact that diversity fosters innovation (Subrahmanian et al., 2020).

A second pillar for our framework, suggested by the authors' experience in policy making processes, is the need to account for the fact that attributing the property of being innovative to an item is a matter, for the individual attributing the property, of becoming aware of new *possibilities* that the innovative item exemplifies or hints at. Our proposed framework aims to account for this basic aspect of the phenomenology of innovation, by theorizing the role of the modal statements that individual *i* holds. In line with this observation, the key idea that this paper is devoted to formalize, is that innovation is a property that an individual attributes to an item when, as a consequence of her/his encountering this item, this individual becomes aware that something s/he implicitly deemed to be impossible is then possible.

Recall that, as explained in the introduction, our methodology consists, at a first step, in formalizing key ideas so as to be able, at a second step, to test their relevance empirically. The fact that these ideas stem from experience hence cannot undermine the scientific credential of the theory, since its relevance will be empirically tested in the end.

To formalize the two pillars above, let us define X_i as the space of sets *x* of modal statements held by *i*. Some of these statements are explicitly endorsed by *i* (meaning that *i* thinks that these statements are true), while the others are only implicitly endorsed. Sets of modal statements are used here to replace the problematic notion of "object" used in classical C-K theory. By talking about sets of statements held by *i* or by people in a group, we usefully avoid having to talk about the absolute truth or falsity of propositions: the point here is not to establish if this or that statement is true of false, but to explore, empirically, the statements that people hold at a given point of time, in given circumstances.

We do not have to admit that anyone can be able to extensively identify the set of modal statements corresponding to a member of X_i. And, clearly enough, when asked about it, individuals typically are not able to say more than the list of modal statements that they explicitly endorse. Take for example the "object" chair. Most people explicitly admit that "a chair necessarily is a piece of furniture", "a chair is possibly made of wood", "a chair is possibly colorful", etc., and most people implicitly admit that "a chair is necessarily a solid object", "a chair is necessarily visible", etc. These sets of explicit and implicit modal statements delineate what a chair is for most individuals. Among the implicit modal statements concerning chairs, one might be "a chair necessarily has four legs".

On this basis, let's define $K(X_i)$ as the set of knowledge which is relevant for X_i (among the statements that this set contains, one can find statements of facts derived from observations, modal statements derived from scientific laws, probabilistic statements derived from statistical generalizations, and modal statements spelling out regulations and rules).

Saying that a statement s in $K(X_i)$ is "relevant" can mean 1) either that s contains a reference to a *x* in X_i, 2) or that s contains a reference to a category of which x is an instantiation, 3) or that a conjunction of several members of $K(X_i)$ contains a reference to a category of which x is an instantiation. We can start by admitting that there is no statement or conjunction of statements from $K(X_i)$ which contradicts the explicitly endorsed modal statements in $X^{expl}{}_i$, because otherwise it would mean that *i* is deeply confused.

Among the relevant statements in $K(X_i)$ one can be: "three-legged objects can be stable". This statement is liable to undermine the above implicit modal statement ("a chair necessarily has four legs"), because it implies that three-legged chairs can be stable, which undermines a prominent reason why one could implicitly think that chairs should be four-legged. Notice that the X_i space is, by definition, associated with a given individual *i*, but an object such as "chair" can find a place in many different X_i.

Two important questions at this stage are: how can one elicit implicitly and explicitly held statements? How can one distinguish implicitly held statement from explicitly held ones? To answer these questions, we do not have to admit that anyone can have access to the whole set of implicit held statements. Explicit vs. implicit can be distinguished depending on the approach used to query people about these statements. If you ask open questions, such as "what are the features that a chair has in your opinion?" then people will answer by spelling out their explicit knowledge. By contrast, if you want people to express their implicit knowledge, you have to ask closed questions, such "do you think that a chair can have less than four legs?", in such a case people might reply "well, now that you are saying that, I figure that a three-legged chair might exist, but I would not have thought about that if you had not asked". In that case, we would conclude that "a chair necessarily has four legs" used to be part of the respondent's implicit knowledge about chairs.

This process of becoming aware of implicitly held statements can also happen spontaneously, as knowledge evolves, or as *i* comes to tackle new problems, which leads them to question some of the assumptions they used to take for granted.

In both experimental and spontaneous settings, *i* becomes aware that s/he used to implicitly hold modal statements that were not that crucial after all and should be abandoned while clinging to other related statements s/he holds.

Within the C-$K^{E/I}$ framework, an act of creating hence qualifies as an innovation for an individual *i* if and only if its output leads *i* to becoming aware of her/his implicit endorsing modal statements that the output leads her/him to abandon. In other words, when applied to the appraisal of the innovativeness of policy alternatives, our approach claims that the core of innovation is the identification of alternatives that used to remain unseen due to unwarranted implicitly held modal statements that were discarded.

This framework is "pragmatic" in the linguistic sense of the term, i.e., as opposed to "semantic": it decisively pays attention to the way language is used.

If applied to innovation in policy design, the C-$K^{E/I}$ framework will be typically used in pluri-individual settings, in which a group G replaces the single individual *i* mentioned so far. In most cases, the relevant group to consider when investigating the innovativeness of policies is the group of stakeholders. Analysts striving to identify innovative policy designs typically deal with different stakeholders (equipped with different goals, backgrounds, initial problem formulations, etc.) endorsing, both explicitly and implicitly, different statements. Therefore, an important part in any investigation about innovative policy design will be to clarify at the outset the focal group for which we want the policy to be an innovation. In some cases, G might be a group of experts who want innovations to emerge because they face a situation where standard solutions are inapplicable. In other cases, G might be a group of concerned local actors, who want the solution to their problem to be heralded as a flagship, and so on. In any case, assessing innovativeness at the scale of G will involve, either using an aggregation mechanism or the collective co-construction of enough homogeneity within G. Both options fall beyond our scope in the present article. Within this context, assuming that groups are sufficiently homogenous to apply the logic delineated above, in the following section we apply the proposed C-$K^{E/I}$ framework to the case of the Apulia Region water protection policy to highlight that the core of innovation is the identification of alternatives

Table 1
Explicit and implicit modal statements relative to the alternative "shared management of the GW aquifer".

Alternative: Shared management of GW aquifer [considered to be innovative by F and IC]		
Explicit/Implicit propositions	Stakeholders	Propositions
Explicit	RA	GW use cannot be ruled but with a tariff
Explicit	IC	GW use cannot be ruled but with monitoring systems
Explicit	RA, Expert in physical models	GW use must be drastically reduced due to the bad state of the aquifers
Explicit	IC, RA, Expert in physical models	In case of drought, GW cannot be used
Explicit	IC, RA, Expert in physical models	Seawater intrusion is the consequence of GW over pumping
Explicit	IC, RA	F use SW managed by IC only
Explicit	F	F use GW
Explicit	RA	The territory is wide, monitoring GW directly use is expensive
Explicit	Expert in agricultural economy	GW has a distributed distribution system, SW has a centralized distribution system
Implicit	IC	W can be managed only by IC → the idea of shared management discards this proposition implicitly held by IC => innovative for IC
Implicit	IC	GW distribution system can be managed too → becoming aware thanks to an intervention of an expert in agricultural economy and Ostrom's principles of governance of the commons explaining the specificities of a shared GW management led IC to discard this implicitly held proposition. In detail, while SW is generally characterized by a centralized distribution system, GW aquifers are highly distributed on the territory, this was considered a constraint rendering its management by a centralized authority impossible. However, the shared management of a GW aquifer would be possible if we move from a command and control approach to the reward/responsibility principles => the idea of shared management discards this proposition implicitly held by IC => innovative for IC
Implicit	IC, RA, F	GW cannot be managed by F → the examples and idea of a shared GW management led F to discard this implicitly held proposition => innovative for them
Implicit	F	It is not possible to know the evolution of the quality state of the aquifers → the information shared by the experts on the water analysis, led F to discard this implicitly held proposition => innovative for F
Implicit	F	The well are in my private property and I obtained the license, I can use GW without constraints → the information shared by the experts on the difference between formal ownership and the right of use of the resource, led F to discard this implicitly held proposition => innovative for F

that used to remain unnoticed due to unwarranted implicitly held modal statements.

4. Application of the framework to innovative policy design to manage water resources in the Apulia region

In this section, we propose to use the above-described framework to analyze ex-post a policy design process. We provide a detailed presentation of the process and show how our framework allows understanding why the various people involved considered some policies to be innovative. Our ultimate aim is to identify how such a process could be piloted from the start to produce as much innovation as possible.

Our case study is an experimental work designed to help a group of stakeholders identifying solutions to the water management problem in the Apulia Region (for details on the case study see Pluchinotta et al., 2019). Briefly, the main objective of the case study was to generate policy alternatives, in order to reduce the dependence of the agricultural sector of the area on the ground water (GW) and surface water (SW), ensuring a suitable water (W) volume for the agriculture. The experiment brought together stakeholders, experts, institutional and non-institutional actors aiding them to find new ways of working together efficiently, generating novel possible alternatives, and encouraging longer-term thinking. It facilitated the transfer of knowledge, enabling participants to embed learning back into their organizations. The main stakeholders and participants of the C-K theory-based policy design process were Farmers (F), the Irrigation Consortium (IC) managing the SW, and the Regional Authority (RA).

The C- and K- spaces of generating the policies of the case study are described in Pluchinotta et al., 2019. For the purposes of the present paper, here we propose to analyze three policy proposals that were considered innovative by at least some of the actors involved. We show that, in each case, when people deem that a given alternative is innovative, we can identify a modal statement relevant to this alternative, which is such that those people used to hold this statement implicitly but figured, thanks to the collective discussion process, that this statement should be discarded. This mechanism is a specific case of the general process studied by C-K theory, but here modal statements, interplays between implicitly and explicitly held modal statements, and the relativity of innovativeness assessment, which are the hallmarks of our refined version, play a key-role. We thereby illustrate how our framework accounts for people's apprehension of innovativeness. The information reported in the following tables summarizes data gathered from meetings and workshops notes, and ex-post discussions between the authors.

The first alternative is the development of a shared management of GW aquifers. All the stakeholders, i.e., F, IC and RA, considered this alternative to be innovative. As illustrated in Table 1, IC and RA used to implicitly admit that IC was the only possible manager for GW too. Experts in physical models and agricultural economy were also involved in the process. This idea underlined all their discourses during the discussions because IC was considered the only suitable authority managing all the water resources (SW and GW). However, this idea was immediately discarded when the new knowledge on the shared management of the GW aquifers was introduced (K-space expansion). The alternative of shared management therefore appeared innovative to the stakeholders. Similarly, F used to admit that they could not be involved in GW man-

Table 2
Explicit and implicit modal statements relative to the alternative "Drought early warning system".

Alternative: Drought early warning system [considered to be innovative by F and IC]		
Explicit/Implicit propositions	Stakeholders	Propositions
Explicit	IC, RA	In case of drought, GW cannot be used, due to the reduced quality and quantity
Explicit	IC, RA	F need to adapt their crop plan to the IC rainfall forecast
Explicit	F, IC, RA	F choose profitable and water-demanding crops over rain-fed crops
Explicit	F	It is difficult to change drastically from water-demanding crops to other crops due to the automatic harvesting process (via crop harvesting tools)
Explicit	F	It is expensive to invest in other crop harvesting tools
Explicit	IC, RA	F use only SW managed by IC
Explicit	F	F use GW
Explicit	F	The crop plan cannot be modified in a short time frame, due to the contracts, advance capital, work schedule, etc.
Implicit	F, IC	It is not possible to forecast drought events in advance → the information shared by the experts on the drought watch systems, led F and IC to discard this implicitly held proposition => innovative for F and IC
Implicit	F, IC	The information on the yearly water availability cannot be shared before the beginning of the agricultural irrigation season → the awareness on technologies for the earlier information, led F and IC to discard this implicitly held proposition => innovative for F and IC

Table 3
Explicit and implicit modal statements relative to the alternative "Water transport from other regions".

Alternative: Water transport from other regions[considered to be innovative by F]		
Explicit/Implicit propositions	Stakeholders	Propositions
Explicit	IC, RA	In case of drought, GW cannot be used
Explicit	IC, RA	F need to adapt their crop plan to the IC rainfall forecast in a short timeframe
Explicit	IC, RA	F use only SW managed by IC
Explicit	F	F use GW
Explicit	IC, F	It is expensive to transport more water from other regions
Implicit	IC	We already transport water from other regions, it is not possible to increase the volume already transported

agement, presumably because (i) the authority of IC for this activity is traditionally accepted and (ii) the knowledge of a shared management of a common pool resource was not held before the experiment. This assumption was shared by F but not explicitly expressed or endorsed. This assumption was discarded when the idea of a shared management emerged, and the latter management option was hence seen as innovative by F.

The second alternative (Table 2) that was considered to be innovative by F and IC was the setting up of a drought early warning system, thanks to an expert who showed examples of how such systems work. In this case, the key propositions implicitly accepted by F and IC were that drought cannot be forecast and, relatedly, that the information on the yearly water availability cannot be shared before the beginning of the agricultural irrigation season. As soon as references to forecasting and information sharing tools started to surface in the discussions, they progressively figured that numerous tools, among which several they already knew about, could perfectly work to foresee droughts in a relevant and sufficiently early way. The early warning system was hence seen as innovative by F and IC because it led them to discard the implicitly held assumption that droughts cannot be forecast and information on water availability cannot be efficiently shared.

The third alternative (Table 3) considered was the transport of water from other regions. The Apulia Region does not hold SW sources, and GW is difficult to reach in several parts of the region bringing several issues related to its quality and quantity. For this reason, the region already imports fresh water from the regions nearby. It has one of the longest aqueducts in Europe and a system of dams, built in the 1900s. Based on these facts, F implicitly assumed that it is not possible to increase the volume already transported. By contrast, other actors such as IC knew of existing, technically feasible means to transport water from other regions and thereby provide a solution to the problem facing F. As discussions unfolded and started to mention these technical possibilities, F figured that their above-mentioned implicit assumption was not warranted, which led them to this alternative as innovative.

5. Conclusions

Innovating in designing policy alternatives is an urgent and major challenge for policy makers, the general public and scientists concerned to contribute to address current problems of global concern, such as environmental crises or widespread socioeconomic inequalities. While the literature in political science is almost silent on this key issue, design theory has developed tools, most prominently C-K theory, which proved very fruitful in their application to the design of marketable objects, but have barely been applied to policy issues. We have shown here that standard C-K theory can become more relevant and practical for applications in policy design if supplemented by a dedicated framework, which we have introduced. This work hence intends to contribute to rationalizing policy design by clarifying a conceptual framework ($C\text{-}K^{E/I}$) demonstrably empirically relevant. Our pilot application to water management in Apulia Region illustrated the relevance and operationality of this proposed framework. Full-fledge large-scale empirical validation in randomized experimental design fall beyond our scope. Further empirical applications are needed to confirm its usefulness.

Future studies should also explore other design theories (beyond C-K theory) to assess their promises, in an approach paralleling what we have done here. Similarly, because innovation in policy design is only one aspect of the policy cycle, analyzing the other aspects of the cycle through the lenses of our approach can also be promising to improve policies.

At a conceptual and formal level, future work should strengthen formalisation by building on relevant insights from the literature in philosophy and theoretical computer science. Philosophers have extensively studied different mental attitudes (beliefs, intentions, acceptance, etc.) and explored their relations (Bratman 1992, Cohen 1992, Tuomela 2000, 2002). The interplay between individual and collective attitudes (like common belief and common knowledge) has also been investigated in artificial intelligence (Fagin et al., 1995, van Ditmarsch et al., 2007, Herzig et al., 2009), based on modal logic with a standard possible world semantics. These various approaches could pave the way for further developments or our framework.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Apulia Region case study – ex-post analysis about generated policy alternatives, implicit and explicit modal statements (from Pluchinotta et al., 2019)

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