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Decision making under deep uncertainty for pandemic policy planning

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ABSTRACT

Policymakers around the world were generally unprepared for the global COVID-19 pandemic. As a result, the virus has led to millions of cases and hundreds of thousands of deaths. Theoretically, the number of cases and deaths did not have to happen (as demonstrated by the results in a few countries). In this pandemic, as in other great disasters, policymakers are confronted with what policy analysts call Decision Making under Deep Uncertainty (DMDU). Deep uncertainty requires policies that are not based on 'predict and act' but on 'prepare, monitor, and adapt', enabling policy adaptations over time as events occur and knowledge is gained. We discuss the potential of a DMDU-approach for pandemic decisionmaking.

Introduction

Most of the EU and US (short-term) strategies in response to the global COVID-19 pandemic can be characterized as (a) transmission prevention, (b) COVID-19 patient treatment, c) stimulating medical innovation, and d) preparing healthcare and society for the worst case, such as insufficient availability of intensive care beds or societal lockdown. These strategies have shown serious limitations, as the social and economic consequences of lockdowns were unprecedented, and thus impossible to forecast. Moreover, it would have been difficult to prepare for the worst-case and risk under/overspending while distracting attention and workforce from prevention, treatment, innovation and preparation for worst case. Policy adaptations were generally made *ad hoc* (daily/weekly) in response to ongoing developments and events, with little underlying strategic thinking or analysis, as evidenced by frequent press conferences in most countries.

This *ad hoc* policymaking is due to policymakers' confrontation with what policy analysts call situations of DMDU. Under conditions of deep uncertainty, experts do not sufficiently know (i) the external context of the system, (ii) how the system works and what its boundaries are, and/or (iii) the primary outcomes of interest from the system and/or their relative importance [1]. These characteristics of deep uncertainty perfectly match the medical, economic, and political policymaking in the COVID-19 case, where we did not know and/or disagreed on (i) how COVID-19 would develop, (ii) how the system (e.g., region) would respond to COVID-19 and interventions (uncertain behavior), and (iii) how this would affect outcomes of interest (e.g., in the fields of healthcare, economy, social wellbeing, etc.), as well as the trade-offs in other societal domains by focusing on specific outcomes (e.g. IC beds occupied).

In general, situations of deep uncertainty require policies that are not based on 'predict and act', but on 'prepare, monitor, and adapt', enabling policy adaptations over time as events occur and knowledge is gained. In this paper, we describe the framework we use for DMDU and its potential for pandemic decisionmaking.

Decision making under deep uncertainty: framework and approaches

Uncertainty can be defined as having limited knowledge about future, past, or current events [2]. Concerning decisionmaking, uncertainty refers to the gap between available knowledge and the knowledge necessary to make the best policy choice. This uncertainty is subjective, depending on the satisfaction of the available knowledge and the underlying values and perspectives of the involved decisionmaking parties. This subjective valuation of uncertainty becomes a trap when implicit assumptions remain unexamined or unquestioned. Moreover, uncertainty can be associated with all aspects of a problem of interest (e.g., the

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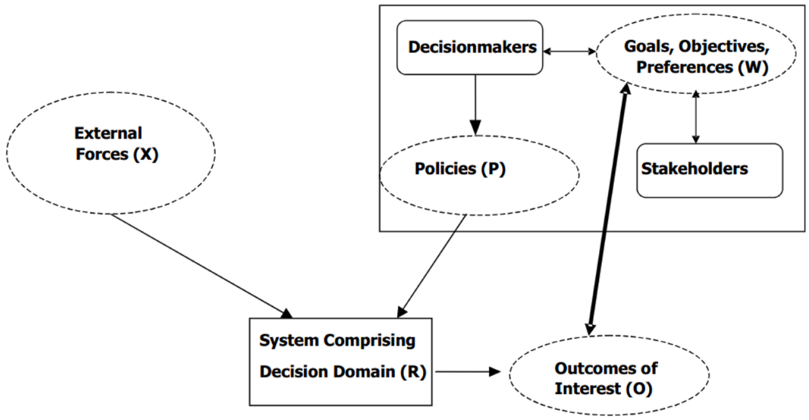

Fig. 1. Framework for decision support from [4].

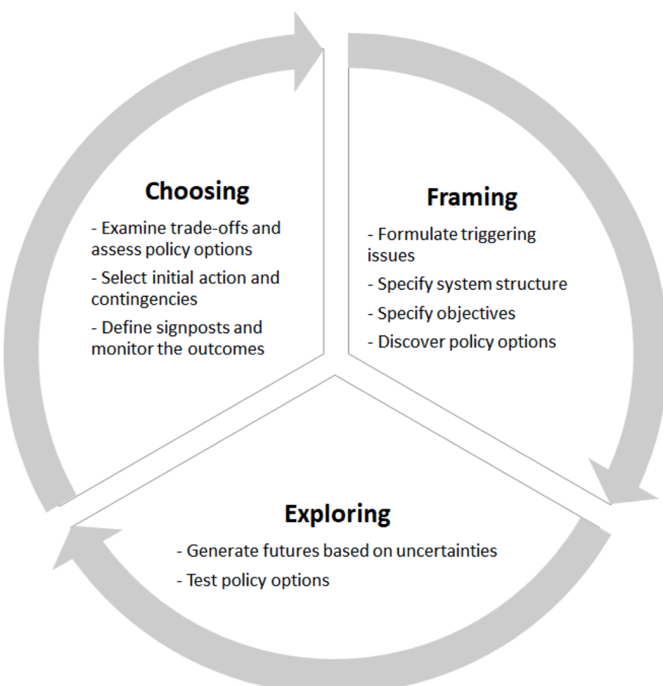

Fig. 2. The Phases of DMDU Approaches – Adapted from [4].

system comprising the decision domain, the world outside the system, the system's outcomes, and the value stakeholders give to various outcomes from the system). Deep uncertainty involves the highest level of uncertainty, where the future cannot be predicted (using probability-based approaches) or a few plausible futures cannot be assumed (using scenario-based approaches).

Under conditions of deep uncertainty, policymaking needs to focus on reducing the vulnerability of a strategy or policy. DMDU conceptualizes decisionmaking similarly to policy analysis [3], where decisionmaking involves steering a system in a desired way. More particularly, given the goals and preferences of crucial stakeholders and decisionmakers (W), decisionmaking involves choosing among policies (P) to achieve outcomes of interest (O) of a system (R) (see Fig. 1). In addition to policies, external forces (X) act upon the system. These forces are outside the decisionmaker's control but are highly relevant for the system's functioning (R) and, thereby, the outcomes of interest (O). Examples of external forces within pandemic management include vaccine developments, virus changes, and political changes.

As indicated, under deep uncertainty, predictions are impossible or highly contested, and decisionmaking has to shift to a 'prepare, monitor, and adapt' approach, which consists of the following phases [4] (Fig. 2):

I **Framing the analysis,** also known as 'setting the scene'. This involves: formulating the problem(s) (or opportunities), specifying the boundaries and structure of the system of interest (R), identifying the actors who will be involved in or affected by the decisions, eliciting their objectives and outcome indicators (quantitative or qualitative) (O), and identifying the enablers and constraints to possible solutions. The analytical approach followed in the remaining phases is also determined in this phase.

II **Exploring uncertainties** concerns the outcomes (O) of policy options and the valuation of the outcomes (W). Outcome uncertainty can result from uncertainty in the external inputs (X) and/or the system responses (R) to these external inputs. Uncertainty about outcome valuation (W) is when it is unknown how stakeholders value the results of the changes in the system. This phase involves 'stress testing' of the policy options in terms of the outcomes (O) for a variety of external circumstances (X), alternative system models (R), and different value systems (W). In summary, this phase identifies the vulnerabilities and opportunities that would determine the failure or success of different policy options.

III **Choosing initial action and contingencies** entails making trade-offs and assessing different policy options given the vulnerabilities and opportunities of alternative policies. Here, initial actions are selected, and means for future adaptations are identified. A monitoring system specifies what should be monitored (signposts), when adaptations should be implemented (triggers), and what adaptations might be required over time.

These three phases and their elements underpin various analytical DMDU approaches. Their underlying paradigm is the need for actions to reduce a policy's or strategy's vulnerability to uncertain future developments. Dewar et al. called this "Assumption-Based Planning" (ABP) [5]. Within this paradigm, analysts use "Exploratory Modeling" (EM) and "Scenario Discovery" (SD). EM is a tool to explore a wide variety of scenarios, alternative model structures, and alternative value systems based on computational experiments. Each experiment involves running a specific model structure and related parameterization to explore various options of real-world behavior. By running many experiments, insight is given into how the system would behave under a large variety of assumptions [6]. SD is a tool to distinguish futures in which proposed strategies meet or miss their goals [7]. It begins with a large database of model runs (e.g., from EM) in which each model run represents the performance of a strategy in one future. The SD algorithms identify combinations of future conditions that distinguish the cases in which the policy or strategy does or does not meet its goals.

ABP was a first step towards an evolving set of analytical approaches

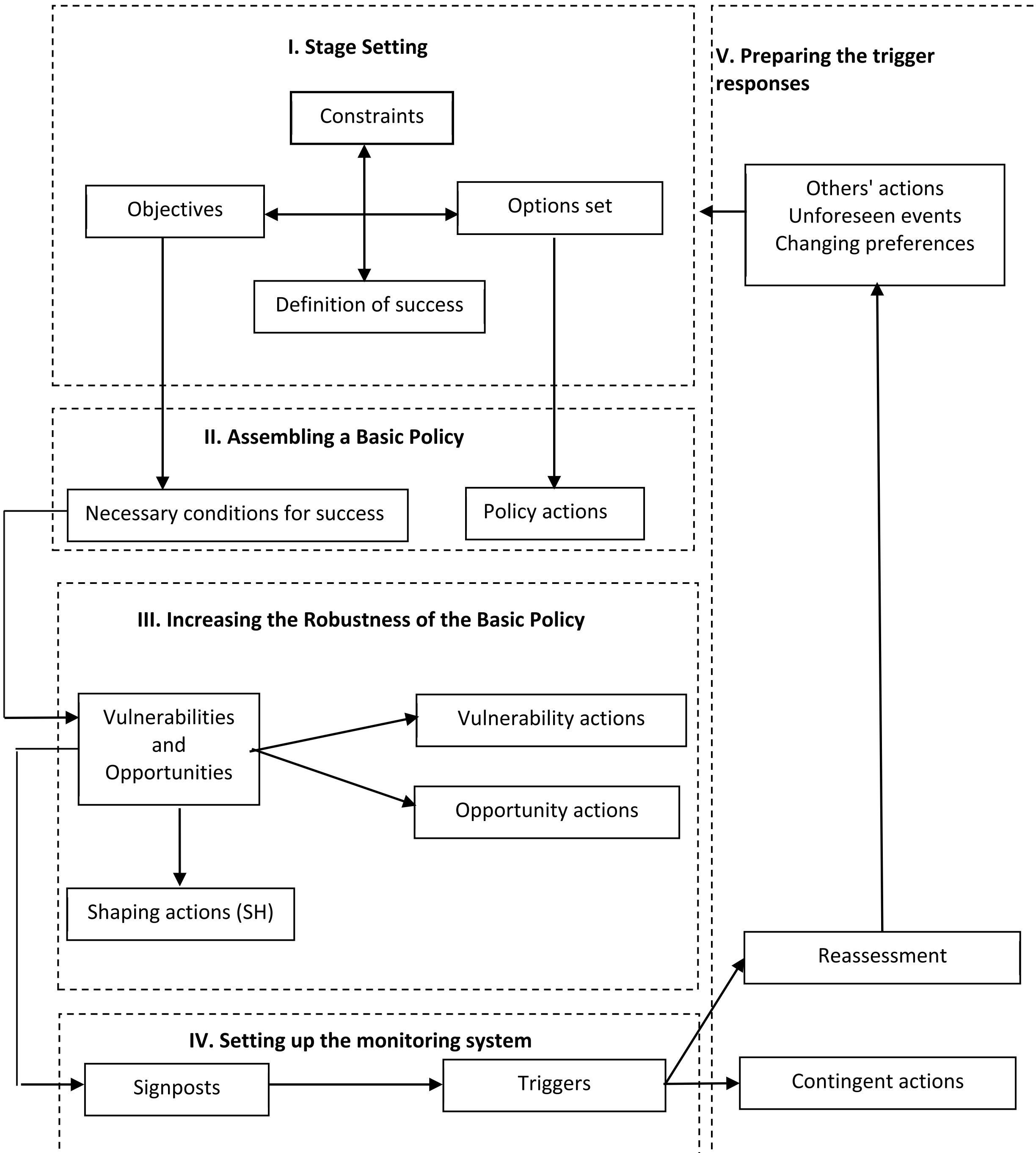

Fig. 3. The DAP design process.

for supporting DMDU. Four of the most commonly used approaches in DMDU are *Robust Decision Making* (RDM) [8], *Dynamic Adaptive Planning* (DAP) [9], *Dynamic Adaptive Policy Pathways* (DAPP) [10], and *Engineering Options Analysis* (EOA) [11]. DAP resembles the Plan Do Check and Act (PDCA) approach of quality improvement cycles, as is often used in healthcare practices [12]. All the DMDU approaches mentioned are improvements over 'predict-and-act'. DAP is only one of them. But, it gives the reader a specific insight into all of the approaches.

DAP consists of 5 steps (see Fig. 3). Step I involves framing the triggering issue where the objectives, constraints, and available policy options are specified. This should lead to the definition of success — i.e., the specification of desirable outcomes. Step II involves assembling a *basic (promising) policy*, with the required conditions to succeed. The rest of the policy is specified in Steps III to V of DAP. These steps make the policy adaptive by identifying the vulnerabilities and opportunities of the basic policy (i.e., how can the policy fail or succeed?) and specifying actions to be taken in anticipation (Step III), defining signposts and triggers to monitor uncertain developments and events (Step IV), and specifying responsive actions to handle these uncertainties if needed (Step V).

Once the dynamic adaptive policy is designed through the five design steps, this basic policy is implemented (together with the actions to be taken immediately), and monitoring commences. Adaptation is suspended until a trigger event is reached. If the original policy objectives and constraints remain in place, these responses are adjustments to the basic policy. If the original policy objectives and/or constraints do not remain in place the entire policy might have to be reassessed, substantially changed, or even abandoned. If so, the following policy deliberations should not start from scratch as they could benefit from the initial adaptive policy design.

Reflection and conclusion

DMDU approaches have been successfully applied in several domains by, among others, members of the DMDU Society. In particular, climate change policymaking and water management have been successful in applying DMDU approaches (e.g., [13]). So far, there is no hard evidence that DMDU will work well for handling pandemics. However, decisions based on predictive models have been shown to fail both in pandemic developments and in societal stress effects [14,15]. Fragments of the recommendations resulting from such unreliable models were implemented with poor results in various regions and countries in response to the COVID-19 pandemic. In contrast, South Korea set up a monitoring system to monitor real-time developments and effects of their pandemic decisionmaking, and prepared contingency plans. Thereby they could act quickly and adequately. The United States did not act according to DMDU principles but primarily relied on forecasting models. South Korea and the U.S. discovered their first cases on the same day. As of March 17, 2023, South Korea had 665 deaths per million population; the U.S. had 3437 deaths per million [16].

Sachs, et al. pinpoint the multiple shortcomings and failures of global and national responses to the COVID-19 pandemic [17]. More importantly, the WHO has agreed on the current development of international legislation on pandemic preparedness (a "pandemic treaty") that sets in place new, global architecture for dealing with future outbreaks to avoid the disastrous effects and mistakes of COVID-19 [18].

Pandemic policymaking needs a shift from 'prepare and act' to 'prepare, monitor, and adapt'. DMDU approaches (one explained in this paper for illustrative purposes) can contribute to a substantial framework for adaptive policymaking. In the deeply uncertain context of a pandemic DMDU approaches can help to recognize needed actions for the success of an initial policy and planning adaptations as triggering points become reality. The key to the success of the 5-phase policymaking approach suggested above is the capacity to respond by initially implementing parts of the policy and maintaining the ability to monitor and flexibility to adapt the policy as the situation changes. The capacity to implement must be available immediately in case of a catastrophic pandemic outbreak – i.e., the capability to monitor and implement the initial policy. But there is also a need for a specific plan to be in place to continuously prepare updates to the policy — applying new insights, adding new tools, using new/revised metrics, and taking into account ways in which society is changing in its structure and functioning as a result of the pandemic.

Declaration of Competing Interest

We declare that:

We have no conflicts of Interest.

All authors meet the criteria for authorship stated in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals.

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