Participatory System Dynamics Modelling for Adaptation to Extreme Hydrological Events under Conditions of Climate Change

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The reduction of vulnerability of water-constrained regional economies to extreme hydrological events can be achieved only through improved understanding of the stochastic regional socioeconomic system dynamics (SD) under conditions of exogenous natural impacts. The frequency and severity of future disrupting features may be very different from today's reality when adverse climate change is considered.

We present a generic integrative modelling approach, the Interdisciplinary Knowledge Integration (IKI), to incorporate multidisciplinary knowledge on essential drivers of a decision context. IKI is an essential element for many environmental applications, including climate services provision (van den Hurk et al., 2016). IKI is applied to adaptation to extreme hydrological events in a water-constrained region under conditions of climate change, with a case study of the Júcar River Basin, Spain.

Central to the IKI process is SD modelling. SD models (Forrester, 1971; Sterman, 2000) are extensively used in describing economic dynamics and economic decision making, including participatory-based techniques of SD modelling co-development (Vennix, 1996; Videira et al., 2017; Voinov and Gaddis, 2017). SD modelling is applied to environmental and climate economics, and to the analysis of climate and environmental policymaking, including water resource management problems.

IKI approach is intended to address the incomplete knowledge of complex SD to support well-informed decisions and policy making, notably for adaptation to climate change.

IKI approach can be highlighted with the following sequential scheme:

a) problem identification and structuring using individual model building exercises with stakeholders;
b) problem analysis using group model building exercises;
c) a family of integrated models (with different complexity levels) to provide results that can be used at the local level for decision-making; and
d) simulations showing efficiency tendencies supporting the optimization of the decision process.

IKI is in essence a participatory modelling approach allowing the inclusion of various complex system perspectives in the modelling framework. The core idea of the approach is building a quantitative modelling structure for a given decision context (e.g., water resources management) allowing the analysis of multiple decision-drivers and their interactions. Transdisciplinary knowledge is included in the modelling framework through the participation and co-operation of stakeholders and researchers in the model creation process.

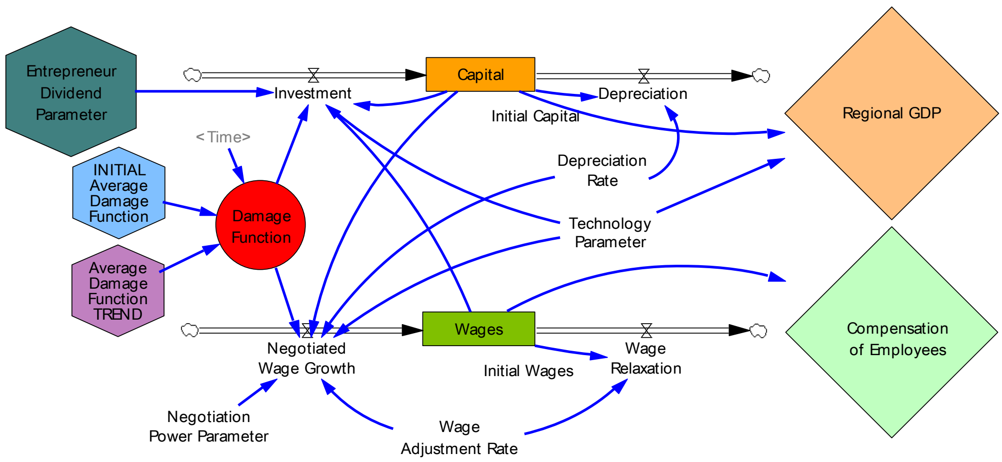
Within the IKI approach, a generic model family is being developed. The term 'model family' is close in its meaning to the model ensemble, but also acknowledges that the member models might be:

- tailored to model different processes and answer different research questions;
- based on different modelling methodologies; and
- applicable to different spatial and temporal scales.

Below we provide a brief description of the root SD hydroeconomic model as the simplest member of generic model family developed within EU H2020 IMPREX project for Júcar River Basin, Spain.

The model is based on a new stochastic version of a SD model SDEM (the Structural Dynamic Economic Model). This model considers the stochastic climate/drought damages affecting the regional economic dynamics as exogenous random shocks. Earlier versions of SDEM were developed by Barth (2003), then refined by other authors (Kovalevsky, 2014, 2016; Kovalevsky and Hasselmann, 2014).

The stochastic version of SDEM presented here is developed from a model previously presented in (Máñez Costa et al., 2017). The derived model incorporates regional economic dynamics with a climate/drought damage function increasing over time (as opposed to constant climate damage function first adopted by Máñez Costa et al. (2017)). This allows for modelling regional change under conditions of gradual increase of severity of extreme hydrological events caused by global warming. Additionally, the derived model is now calibrated to reproduce regional macroeconomic dynamics in Júcar River Basin, Spain.



Modelling results show that the introduction of stochasticity into climate/drought damage scenarios leads to substantial uncertainty in simulated projections of regional macroeconomic dynamics. In 20 years, uncertainty related to stochastic effects becomes equally important as compared with 'deterministic' uncertainty related to assumptions about deterministic trends in climate/drought damages.

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