

GLOBAL SYSTEMS SCIENCE

An Emerging Research Field

The societal challenges facing the world are substantial. Two major aspects, the connectivity across subject domains and globalisation, are putting demands on decision makers for which the available tools provide insufficient guidance. Humankind has reached a situation where existing policy instruments are clearly unable to provide sustainable outcomes on a global scale. The challenges laid down by an increasingly integrated market economy, by climate change and other environmental threats, food security, or energy sufficiency are today all *global* in nature. Here ‘global’ means that the challenges are multi-dimensional and borderless. Consequently they can no longer be handled by one given country, by one aspect of policy.

We require a new way of thinking. There is a need for a new science which takes into account connections across national borders, and across policy areas such as economy, transport, health and social understanding of system risk. The multidimensionality of global problems - the interconnectedness of decisions across different policy sectors - should be reflected in a multidisciplinary system approach.

Such a science of global systems must pay special attention to the interface with policy *and* society to better ground the scientific tools. Information and communication technology (ICT) will support the massive needs in computing and data handling and help in establishing new links between science, policy and society. New tools enabled by ICT will also help establish better feedback between the community of modellers and model users – policy bodies or societal actors in order to overcome the shortcomings in the models that support decision-making and secondly, implement new forms of global governance.

Two pertinent areas for Global Systems Science are:

Overcoming the shortcomings of existing models in support of decision-making

While there are many areas which require attention, economic model development after the financial crisis is a pertinent and urgent case study. The crisis has shown us that the real economy is more globalised and integrated than the models used before and during the crisis allowed. The interdependencies within the financial system and the tight links of the financial systems with all sectors of economy have lead to dangerous chain reactions and contagion of crises not anticipated in current economic models.

Jean-Claude Trichet from ECB concurs: *“The key lesson I would draw from our experience is the danger of relying on a single methodology or paradigm. Policy-makers need to have input from various theoretical perspectives and from a range of empirical approaches. Open debate and a diversity of views must be cultivated.”*

New models of global systems are now creating increasing interest among policy-makers, who are looking for alternatives to existing theoretical models. This is especially the case for decision-makers faced with challenges in the global economy, the financial markets, the environment, and the energy sectors, but is true across the full range of policy domains. Indeed, many are now aware that even local and regional actions can have knock on effects leading to global consequences.

Progress in modelling of large systems enables the creation of advanced *simulation models* that can reflect factual conditions and human behaviours. The models can include empirical data on systemic dependencies in global economic systems as well as data on social preferences and on the role of human and collective behaviour. Foundational issues raised include new large-scale agent-based modelling, new tools for data analysis, visualization, and formal methods for model specification and model validation. The large scale computing capacity and data infrastructures provided, e.g. by grids, will be important. Likewise, collective and interactive web infrastructures enabling stakeholder participation and interaction between stakeholders in society will play an important role. Also, for instance, applications which seek to identify, predict and avert crisis, through sensor networks and a process of online monitoring with feedback from individual citizens, will play an increasing role in dynamic systems modelling.

Many research challenges remain to be addressed - system architecture, data management, integration, model validation, and interfaces. ICT platforms enable large-scale models to be set up, executed, and validations to be made across competing models. Tools need to be developed to gather/integrate various data - financial data, socio-economic data, data on financial and economic networks, ecological and energy data, and even data on nature of human decision. Model validation is needed both in terms of the underlying assumptions and the underlying parameter choices in order to ensure their consistency and empirically validate them.

Overcoming the limits of traditional forms of governance

The biggest challenge is social. Research is needed to help policy makers understand, trust, and develop narratives for the new generation of models. What questions researchers should be asked, which data should be collected, and how the models should be formulated must be guided by the concrete societal questions and policy decisions ahead. How can scientific modellers communicate/interact better with citizens, business, politicians, government officials and NGO representatives?

A coherent approach to narratives related to models is necessary, using models and data to provide chains of causality from particular actions to specific outcomes, for use in socio-political negotiation and decision-making processes. Global Systems Science is a “science of foresight”. Better models can give policy makers valuable insight on system behaviour and dynamical outcomes, supporting better policies.

At the same time, ICT is triggering fundamental changes to practices both in society and in the social sciences. This opens a vast range of opportunities. The premise is that ICT is the central tool available to scientists, policy makers, and society to tackle global problems. ICT will trigger novel forms of societal/collective organization: it will be a tool to design and co-create our future. Researchers have to critically reflect upon the role of ICT in changing practices both in social sciences and in society and work on the foundational challenges that result.

The present global decision-making order based mainly on nation states cooperating in inter-governmental bodies has proved to be insufficient in addressing the global challenges. Global Systems Science is not sufficient, but certainly necessary to address global governance issues.