First IIASA Summer Workshop on Green Growth Modeling
Advanced Systems Analysis (ASA) and Risk and Resilience (RISK)

Organizers: Asjad Naqvi & Elena Rovenskaya

Date: 26th July, 2017
Time: 14:00 – 18:00
Venue: Givishiani Room, IIASA, Laxenburg, Austria

14:00 – 14:15 Introduction
14:15 – 15:15 Session 1

Emission Permit Trading with Global Externality Problems
Tapio Palokangas

The Social Cost of Carbon Dioxide - Mitigating Global Warming Whilst Avoiding Economic Collapse
Christopher Kellett

15:15 – 15:30 Coffee break

15:30 – 16:30 Session 2

A three-phase model of climate change mitigation
Willi Semmler, Elena Rovenskaya, Julia Puaschunder, and Sergey Orlov

Optimal Control of “Deviant” Behavior
Gustav Feichtinger

16:30 – 16:45 Coffee break

16:45 – 17:45 Session 3

Climate financial bubbles: How market sentiments shape the transition to low-carbon capital
Emanuele Campiglio

Towards Climate-Economy Assessment with Explicit Consideration of Stochastic Discount Rates
Timm Faulwasser, Chris Kellett, Lars Grüne, Willi Semmler, Steve Weller

18:30 – Dinner

Abstracts

Emission Permit Trading with Global Externality Problems

Tapio Palokangas
University of Helsinki, Finland and International Institute for Applied Systems Analysis (IIASA), Austria

This article examines a set of heterogeneous countries where firms produce goods from fixed resources and emitting inputs. Emissions cause global pollution (e.g. GHGs). International environmental policy is run by a benevolent regulator that sets firm-specific emission permits. It is shown that if the firms are allowed to trade in emission permits, then welfare decreases. If the countries selling permits are on the average poorer than those buying permits, then the regulator provides too much permits from the social point of view, aggravating pollution. If vice versa, then the regulator provides too little permits, alleviating pollution.

The Social Cost of Carbon Dioxide - Mitigating Global Warming Whilst Avoiding Economic Collapse

Christopher Kellett
University of Newcastle, Australia

Many governments and international finance organizations use a carbon price in cost-benefit analyses, emissions trading schemes, quantification of energy subsidies, and modelling the impact of climate change on financial assets. The most commonly used value in this context is the social cost of carbon dioxide (SC-CO2). Users of the social cost of carbon dioxide include the US, UK, German, and other governments, as well as organizations such as the World Bank, the International Monetary Fund, and Citigroup. Consequently, the social cost of carbon dioxide is a key factor driving worldwide investment decisions worth many trillions of dollars. The social cost of carbon dioxide is derived using integrated assessment models that combine simplified models of the climate and the economy. One of three dominant models used in the calculation of the social cost of carbon dioxide is the Dynamic Integrated model of Climate and the Economy, or DICE. DICE contains approximately 70 parameters as well as several "exogenous" driving signals such as population growth and a measure of technological progress. Given the quantity of finance tied up in a figure derived from this simple highly parameterized model, understanding uncertainty in the model and capturing its effects on the social cost of carbon dioxide is of paramount importance. Indeed, in late January this year the US National Academies of Sciences, Engineering, and Medicine released a report calling for discussion on "the various types of uncertainty in the overall SC-CO2 estimation approach" and addressing "how different models used in SC-CO2 estimation capture uncertainty.

A three-phase model of climate change mitigation

Willi Semmler
New School for Social Research, NY, USA

Elena Rovenskaya
International Institute for Applied Systems Analysis (IIASA), Austria and Lomonosov Moscow State University, Moscow, Russia

Julia Puaschunder
Harvard University, USA

Sergey Orlov
Lomonosov Moscow State University, Moscow, Russia and International Institute for Applied Systems Analysis (IIASA), Austria

We consider a three-phase optimal control model of economic growth and climate change mitigation through transiting to low-carbon technologies. In the first phase, companies invest in adopting low-carbon technologies and a part of the required investment is reimbursed through 'climate' bonds issued by the government. The second phase starts when the greenhouse gases' concentration is reduced to a pre-industrial level and firms have fully adopted low-carbon technologies. In this phase, bonds are being repaid through taxation. In the last phase, the economy is accumulating capital and consume enjoying the stabilized climate. The standard consumption based utility function in the logarithmic form is applied over all three phases. We use GPOPS-II software to find a locally optimal solution in the model, including the optimal switching times between phases. We compare the obtained optimal solution with a business-as-usual version of this model, in which no mitigation action is undertaken. The social welfare function in the mitigation policy model turns out to be greater than the one in the business-as-usual model over almost the entire time horizon of consideration with the exception of a short period in the beginning of the first phase.

Optimal Control of "Deviant" Behavior

Gustav Feichtinger
Vienna University of Technology (TU), Austria and International Institute for Applied Systems Analysis (IIASA), Austria

For several decades, Pontryagin's maximum principle has been applied to solve optimal control problems in engineering, economics, or management. Early Operations Research applications of optimal control include problems such as production planning, inventory control, maintenance, marketing, or pollution control. Since the mid-nineties, optimal control models of illicit drug consumption have contributed successfully to a better understanding of drug epidemics and their control via an optimal mix of instruments such as prevention, treatment or law enforcement. This talk explains why and how tools of dynamic optimization are used to address pressing questions arising in drug policy. Moreover, methodological advances in optimal control theory that have been triggered by solving these problems will be highlighted, e.g., multiple equilibria & SKIBA thresholds. We discuss social interaction

mechanisms generating this sort of sensitivity of the optimal solution paths from the initial conditions. Another important type of complex solution structures are persistent limit cycles. A standard two-state production/inventory whose solution consists on a stable oscillation is presented. Surprisingly, it contains several indifference curves and a threefold Skiba point.

Climate financial bubbles: How market sentiments shape the transition to low-carbon capital

Emanuele Campiglio
Vienna University of Economics and Business (WU), Austria

The large-scale transition to low-carbon forms of capital stock is likely to have deep implications on involved companies and the market valuation of their financial assets, with repercussion on financial investors holding the assets and potential disruptive systemic effects. We analyze here the link between finance and the low-carbon transition by means of a multi-sector macroeconomic model with two forms of physical capital - high-carbon and low-carbon - and financial investors allocating their wealth across equities issued by productive sectors. In our baseline scenario the low-carbon transition produces some relevant macroeconomic and financial fluctuations, especially when the high-carbon capital sector defaults. We then study how financial market sentiments might affect the shape of the transition. To emphasize the role of the financial sector, we make the counter-factual assumption that low-carbon technologies are less costly to operate than high-carbon technologies. Despite the cost advantage, investor behavior favours the incumbent technology. We allow investors to develop varying degrees of `apathetic' expectations around the development of the low-carbon sector and to hold limited perceptions regarding its actual size. We show that higher levels of `climate apathy' extend the length of the transition period, possibly to the point of preventing it from happening, and produce larger amounts of both physical and financial stranded assets. Our results support the call for increased climate-related financial disclosures and the implementation of policies to help investors reduce uncertainty.

Towards Climate-Economy Assessment with Explicit Consideration of Stochastic Discount Rates

Timm Faulwasser
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To quantify the damages from anthropogenic emissions of heat-trapping greenhouse gases, specifically carbon dioxide CO2, integrated assessment models are used to describe the dynamics of climate-economy interactions. Typically, any computation of the Social Cost of Carbon Dioxide SC-CO2 is based on the solution of a single (long-horizon) deterministic optimal control problem. However, a recent report by the US National Academy of Sciences calls for the development of new frameworks for computation/estimation of the SC- CO2, whereby the explicit consideration of uncertainties shall be a key concern. Therein, two main sources of uncertainties are identified: (i) uncertainty surrounding the considered discount rate and (ii) uncertainty stemming from unknown future evolution of macroscopic exogenous variables (damages, population growth, carbon intensity of industry, etc). In this talk, we discuss the computation of the SC-CO2 via the Dynamic Integrated model of Climate and the Economy (DICE) proposed by Nordhaus. Specifically, we show that tools from uncertainty quantification and systems and control allow deriving a stochastic variant of DICE, whereby the discount rate is assumed to be uncertain, i.e. specified by a non-Gaussian probability density function. It is widely recognized by economists that the correct discount rate is very difficult to select, hence uncertain. While in principle the proposed framework can be extended to other parameters in the DICE model, we focus on the discount rate as just one critical source of uncertainty. To this end, we combine numerical optimal control to compute the SCC with polynomial chaos expansion.