Towards the neXt generation of climate policy models

REPORT

International Expert Workshop
organized by the European Climate Forum
on behalf of the German Ministry for the Environment
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I. Introductory remarks

The workshop „Towards the next generation of climate policy models“ has been organized by the European Climate Forum (ECF) on behalf of the German Ministry of Environment (BMU). If was an outcome of the BMU-funded study „Investments for a climate-friendly Germany” (see *Jochem/Jaeger et al.* 2008), carried out by the Potsdam Institute for Climate Impact Research (PIK), ECF, the Institute for Systems Innovations (ISI) in Karlsruhe, Munich Re (the largest re-insurer and one of the largest investors of the world), and Swisscanto (an association of Swiss banks). According to the study, the German 40% CO_2 reduction goal is feasible until 2020 in an economically advantageous way. The report states that in comparison to a business as usual scenario, Germany could achieve additional employment and increase overall prosperity – but only if considerable additional investments are successfully mobilized. This has been called an „Innovation and Investment Oriented Climate Policy Strategy“.

Assessing the data and trends for the study led the consortium to consider a number of climate policy models, which in turn created a strong need to discuss some future steps for modeling short- to medium-term climate policy decision making in the horizon of de-carbonizing modern economies. The consortium members decided to invite a number of experienced climate policy modellers and discuss with them their own experiences, and to find out what the scientific community would need to come up with in the face of climate policy induced structural economic changes.

Most of the invited responded immediately and were willing to participate on very short notice. Some of those who could not make it to Berlin—the venue of the workshop—did participate virtually via web-presentations and phone exchange.

All presentations are available on the ECF website. For all references given in the text see part IV “Publications and References”.

I thank *Bert de Vries* for valuable input to this report. The usual disclaimers apply.

W.L.

II. Workshop Report

Thursday 13 November 2008

1. Introducion: The Economy as a Complex System - Requirements Concerning 2nd Generation Models

Carlo Jaeger

In his introduction, *Prof. Carlo Jaeger* (*Potsdam Institute for Climate Impact Research* and *European Climate Forum*, both: Potsdam Germany) reminded the workshop participants that an emerging consensus about substantial long-term GHG reductions—as in the EU with its 20% (30% if others follow) or in Germany with its 40% reduction goal until 2020 (base year 1990)—would require a new generation of climate policy models for various reasons. A major theoretical reason can be found in the fact that the actual generation of climate policy models is tuned towards more or less explicit constant boundary conditions within which states of single market equilibria are assumed to shift if, as required by the new climate policy horizon, major transitions in technologies, markets and—possibly—new market-policy boundaries are required. One important requirement for a new generation of models should then include their ability to deal with multiple equlibria.

Jaeger mentioned underutilized resources and equilibrium selection as key examples for this ability of new models to deal with out of simple near-to-equilibrium dynamics. The next generation of climate policy models should also be able to deal with incomplete markets and to explicitly include the financial sector. The current crisis of the financial markets has shown how crucial this sector is when it comes to finance investments (or failing to do so) and to create (or destroy) trust in the economic process. Otherwise openness to the future as a key virtue of the next generation of climate policy models could not be ensured.

As a consequence, the workshop aimed at bringing together international experts which work on comparable models. On this basis, a research strategy has to be designed coping with the task of developing a future generation of climate policy models, focussed on different countries, and on the world as whole.

2. On the Reasons for a New Generation of Climate Policy Models

Stephen DeCanio

Then *Prof. Stephen DeCanio* (University of California, Santa Barbara, USA) whose book on the failure of Climate Change Computable General Equilibrium (CGE) models (*DeCanio* 2003) is an important point of reference for this conference, elaborated on some of the reasons for the need for a new generation of models. He indicated why conventional macro-economic models are great for conventional policy analysis, but do not work well enough for climate policy analysis.

Among a couple of reasons for this he stressed the point that the Kaldor-Hicks Compensation Principle cannot be used because more than this generation is involved in climate issues, and there is no reasonable way that the future generations can compensate us for sacrifices that we might have to make to avoid climate catastrophe. This poses serious challenges to Cost-Benefit Analyis, too.

Following *DeCanio,* it is also the case that while market prices embody a certain tangible reality, this is a reality that also embodies the existing distribution of income and wealth with the current endowments of rights and property. If we are going to solve the climate, however, this will necessarily involve the creation of tremendously important new rights and new kinds of property. The existing equilibrium distribution, depending on current property rights, will not be adequate. *DeCanio* stressed the link to the equity issue at this point, which in his view is really an obstacle to achieving the necessary international agreement.

In modeling different patterns of endowments resulting in different equilibria, following *DeCanio* we have to face the issue of equilibrium choice that was already mentioned in the introduction.

Finally *DeCanio* emphasized the need for Agent Based Models (ABM). The agents' connectedness and the specification of their properties give a way of dealing with bounded rationality – which is in his opinion very important to bring realism into the policy debate. With agent-based models it is possible to do experiments to explore the parameter space in ways that we can't do with actual society, because you only get to run the experiment once. With agent-based models it is possible to do more exploratory work. It is also possible to have operational models of social evolution with agent-based models, which is very important because change and non-equilibrium dynamics is not handled very well in most current models.

Besides that there is the need for governance models, models about how decisions are actually made in modern mass societies. The agent-based approach could give a notion of where hierarchy comes from, and hierarchy is an important part of the social landscape. Models are needed that come to grips with the complexity of social phenomena, e.g. the voter ignorance that makes governance in a democratic society not at all like the simple rational agent models that are common in economics.

Finally, new economic models could show that economics still has a role in all this. They can show cost effectiveness; they can show how to do things in an efficient way. And with regard to risk and uncertainty, economics certainly has something to say about that, as in the recent works of *Martin Weitzman*, showing that the deep uncertainties about the climate system have strong implications for the possibility of doing cost-benefit analysis over time. There can be a contribution from economics in talking about the tolerable windows and safe landing paths – as discussed in work that has been done at PIK (Potsdam Institute for Climate Impact Research, Potsdam, Germany).

He closed with a somehow philosophical perspective: „The future is not determined, it is open. The unique characteristic of human action and human societies is that we do have the opportunity to choose the path down which we want to go. No mechanical model, whether it has a random component or not, is ever going to be able to capture that element of choice and decision. We need to be able to integrate the modelling work with this larger freedom that we have to exercise if we are actually going to solve this problem in the future.“

3. Models at a glance I: Astra

Wolfgang Schade

Next was a presentation by *Dr. Wolfgang Schade* (*Fraunhofer-Institut for Systems and Innovation Research* (ISI), Karlsruhe, Germany) on the ASTRA model (*Schade* 2005). The model has been developed already in the year 2000 but is still a “new” model in the sence of the conference title. ASTRA is an acronym for „Assessment for Transport Strategy“, as it originally was designed to assess transport policy in the European Union. It was one of the first models showing with a detailed policy package that CO2 emissions reduction from transport is actually feasible. In the course of time its coverage has been extended: In its present version it is being implemented for 29 EU-countries and there are 25 economic sectors for each country; in addition there is trade with nine regions of the world. ASTRA now has an overal economic scope and it has been one of the tools used in the “ClimInvest” study done for the German government in 2008 (*Jochem/Jaeger et al.* 2008).

It is a data-intensive model written in Vensim, which uses mostly well-known bottom-up building blocks in the 9 sub models. It runs in about 5-7 minutes, with 800 Mb output data.

In the above mentioned study, one main result was that a 40% reduction in carbon emissions by 2030 is possible without major disruptions in the German economy; the key point is to increase for some years the savings rate (low at present, about 18% gross) and give an investment impulse towards decarbonizing the economy. This will in turn yield not only emission reductions but also considerable productivity increase (from induced technological change), consumer savings (from lower energy bills) and trade balance advantages (from importing less fossil fuel). Analysing this kind of ‘Investment and Innovation Oriented Climate Policy Strategy’ (*Jochem/Jaeger et al.* 2008) would not have been possible with using Computable General Equilibrium (CGE) models only, it required some new methodologies.

4. Models at a glance II: Towards the Next Generation of Climate Models

Tom Fiddaman

Then, a presentation was given from the USA via WebEx by *Dr. Tom Fiddaman* (*Ventana Systems,* Harvard, USA and *MIT Sloan School of Management*, Cambridge, Massachusetts, USA) (with inputs from *Prof. John Sterman, MIT Sloan School of Management,* Cambridge, Massachusetts, USA). He gave an overview of the shortcomings of the existing climate policy Integrated Assessment Models (IAM) such as DICE, FUND, MiniCAM and others. *Fiddaman* argued that the current modelling situation creates some risks that are quite important. One of them is that most of the existing models simply reinforces unsustainable decisions. E.g., you have models (like DICE), which on the one hand are useful, in the sense that they are very transparent, quick, and have been adapted many times. At the same time, they leave out a whole bunch of feedbacks that are in fact quite important. Therefore, we had to live with underestimated climate risks, overestimated mitigation costs, and a neglect to coordinate climate risks with other kinds of risks, or other kinds of problems: national security, poverty, population growth etc. One interesting result of sensitivity analyses is that the response of these models to a fixed carbon tax profile gives an enormous spread in carbon emission profiles – and vice versa.

With regard to the decision makers, *Fiddaman* categorized most models as not really transparent to the user. Because the models tend to be big „they do a lot in generating interest, but they do not do much to improve mental models of the decision makers“. This results in a persistent “wait and see” kind of approach that leads to a bad outcome and goes unchallenged.

Additionally, there was a need to consider a general problem: because of the assumption of a single equilibrium, a number of features of a realistic representation of policies are omitted, and that means when politicians translate the theoretical policy into a real piece of legislation or a real regulation, that policy often is at risk of failure.

Looking at the recent IPCC Report of Working Group 3 (the technical summary), he identified several „knowledge gaps“. Among others, there are problems with regard to the link between climate change and other policies, generally with trying to interpret sustainable development in models. One of the classical problems is the gap between the conclusions of top-down and bottom-up models, which can be to some extent closed by hybrid models. There are other issues as well, including poor coverage of various key sectors and regions.

According to *Fiddaman*, unfortunatelly, the menu of dominant models is about the same today as it was in the third IPCC Assessment Report and even prior to that. Somehow, even though there are lots of interesting behavioural models and other variants, they are not penetrating to the inner circle of decision making.

What would more advanced models look like? Some key elements might be identified:

- Behaviour is probably the most central among them; one needs a representation of delayed foresight, miopy, extrapolation, and other kinds of explicit decision-making characteristics as opposed to perfect foresight achieved through a numerical algorithm.

  A multi-agent approach is needed that actually includes two kinds of things. One one hand side there is the case that diverse agents all solve the same problem, as in the case of a bunch of farmers adapting their cropping patterns to climate impacts and learning from one another in an evolutionary sense. On the other hand, there are e.g. complex interactions needed between fuel refiners, vehicle manufacturers, consumers, and regulators in the transition to alternative fuels.

  According to *Fiddaman*, models need to represent a lot better „how it is that social change works“, because if society is really serious about achieving the conditions needed (for example cuts of 80% or more in emissions) this must be accompanied by broad changes in technical patterns and a whole range of other interacting attributes that happen ultimately through networks of individual people. It would extremely helpful to understand better how that process actually works.

  Finally, another key piece is institutional structures. It is extremely important to understand the legal and social context within which individuals are making decisions.

- Nonlineatrities and positive feedbacks must be taken into account. With regard to endogenous technical development, there has been much effort in the last ten years but, unfortunately, primarily on learning curves even though there is much more to technology diffusion than learning curves.

- Non-Climate goals should be recognized as well (population, poverty issues etc.) and there is a need to integrate categories like goals and values in the model.

As examples, *Fiddaman* compared three different approaches: (1) The Energy Transition and the Economy (*Sterman*, 1981), (2) FREE (*Fiddaman*, 1997) and (3) Alternative Fuel Vehicle Transition Dynamics (by *Sterman*, too). He advocated simple climate models for different reasons: people are operating on a pattern-matching heuristic; it is difficult to translate multilateral emissions commitments, expressed as a mix of absolute, intensity, and effort targets, into an emissions trajectory; negotiations are dominated by non-climate considerations such as oil price and oil depletion; and, finally, decision makers won’t wait for new model runs that take a lot of time to perform.

The conventional framework for climate policy modeling is: identify the optimal tradeoff between abatement and impacts across regions, sectors, fuels, gases… However, models of a new generation might discover actions that control things in our favour where possible, anticipate what is inevitable, and hedge against what is uncertain. Such models might contribute to policy implementation as well.

In the discussion *Fiddaman* stated that it might be useful to complement system dynamics models with agent-based simulations, although this may be hard given the inherent complexity of the problem.

5. Models at a Glance III: Lagom modeG

Carlo Jaeger

The next presentation was by *Prof. Carlo Jaeger* on the Lagom model family. "Lagom" is a Swedish word meaning something akin to harmony, balance, perhaps "Dao" in Chinese. The core team working on this model family is right now *Antoine Mandel, Steffen Fuerst, Wiebke Lass* and *Carlo Jaeger* (see *Mandel et al.* 2009).

The motivation - and somehow urgent need - to develop such a kind of model resulted from the empirical situation in Germany. Germany was a very high investing country a couple of decades ago, and it is now one of the lowest investing countries worldwide. An ambitious climate policy in this country can not be done, according to *Jaeger*, without increasing the investment share. This kind of interdependencies, besides, is some of the background for the development of the 'Innovation and Investment Oriented Climate Policy Approach' (*Jochem/Jaeger et al.* 2008).

With regard to the theoretical motivation, *Jaeger* picked up his introducing remarks on the problem of equilibrium selection. Given the discrepancies in the definition of „equilibrium" (for example economics vs. dynamical systems theory) he preferred to talk about „attractor selection" for the time being. The appropriate theory to the question of equilibrium selection, or attractor selection seems to be convention dynamics: over the last 15 years it has been shown that if you have a socio-ecological system where different social conventions are possible, like shaking hands or bowing for greeting, then the stochastical dynamical features of the process may select which convention you end up with. This interesting piece of theory is used by *Gintis* in his 2007 paper to discuss the problem of attractor selection in economics. Lagom builds on this work, adding key features like heterogeneous capital accumulation and learning by doing.

To understand price dynamics, it is important to recognize information costs: customers need to gather price information, there is no auctioneer who gives it for free. Suppliers need information on their customers. They have to change prices from time to time, but there is a reluctance to do so because of information costs. These aspects are included in Lagom. There is a rate of interest from an explicit financial system, and there is learning-by-doing from investment.

Some agents behave according to rules of thumbs. This is for example the case with the central bank using the so-called “Taylor rule”. Following this, central banks basically have an idea of what is called the natural rate of interest, they have a target inflation rate, they observe actual inflation, they have an idea of the “natural” unemployment rate, and observe actual unemployment. Based on those observations, they take their decisions.

Lagom is a multisectoral model which incorporates heterogeneous capital goods, endogenous technical change and agent-based dynamics. There is a structure of four nested dynamics where for example the actions on the financial market follow a different time regime than the processes on the labour market. The key point is to explore the selection of attractors; in conventional economic models there is only one (“we do not understand supply-demand interaction, the program code simply enforces a single attractor to avoid the resulting mess”.). In Lagom, labor productivity is an explicit function of investments, and the input-output coefficients (production technology) evolve in a genetic fashion. Agents (firms, consumers) interact (e.g. imitation) according to stochastic matching rules. Economic change emerges due to the fact that new firms are created in profitable sectors and that the most unprofitable firms go bankrupt.

The software environment is the MASON library, written in Java-5 at George Mason Universities (GMU) School for Social Complexity (*Prof. Robert Axtell*).

Currently, the model is in its initial stage. The focus is on statistical properties of large numbers of runs (this is similar to the use of Dynamic Stochastic General Equilibrium models). In the most recent version the model is fed with data from the German economy starting from 1978 and the economy is divided into four sectors. The group is working currently on reproducing the past German economic dynamics, adding more sectors and agents and to represent an integrated management of climate and financial risks.

In the discussion the need to better specify the notion of an agent was articulated. Following *Jaeger*, right now, an agent in this system is just a function that takes a state and returns another state. This function can be interpreted with words like: perception, rule, and action. But thinking e.g. at expected income, he personally believes that there is a need for agents with explicit beliefs about the world in the future.

As to the definiton of new climate policy models, *Jaeger* argued that existing models were quite ok for some of the relevant questions. But, in the case of Germany, he was convinced that the representation of the economy as a multi-attractor system is required. If one wants to reduce emissions by 5% in Germany over ten years, the existing models are just perfect. But government has said that it wants to reduce them by 40% by 2020. Then these models are really becoming misleading and something different is needed.

Friday 14 November 2008

6. Models at a Glance IV: E3 Models

Terry Barker

The morning session started with a WebEx presentation by *Dr. Terry Barker* (Cambridge University, Cambridge, United Kingdom) on „Energy-environment-economy (E3) modelling of climate policies from the IPCC TAR to the AR4: why we need more ‚new' economic models". He first characterized the critical differences between traditional and new economics, two types of economics that underly different models. With respect to ethics and society, traditional economics adheres to a utilitarian approach, whereas new economics is closer to observation.

With respect to time and equilibrium, traditional economics assumes full employment on a single trajectory, whereas new economics takes path-dependency and underutilized resources into account. Regarding uncertainty, traditional economics is based upon normal distributions derived from the past, whereas new economics deals with non-linear and potentially catastrophic surprises. With respect to technology, traditional economics assumes an exogenous change with no feedbacks, whereas new economic approaches endogenize technological change (e.g. via climate policy).

Barker than gave an overview of the use of IAMs in the 4th Assessment of IPCC WG3, indicating the enormous uncertainty involved in these simulations and the huge expansion in the number of scenario construction participants. For instance, the EPPA-model has highest cost estimates for CO2-reduction – one reason: electric cars on the USA market were excluded…

Why do we need more 'new economics' models in climate policy models? Advances in understanding are required to improve the analysis of, e.g.:

- Induced technological change
- Multigas emissions
- Recycling carbon tax/revenues
- Co-benefits

Barker gave a scheme with critical differences between traditional economics and new economics in areas *like* ethics and society; time and equilibrium; uncertainty; and technology. The new insights imply, for instance, an emphasis on risks of irreversible loss and limited/non-substitutability. There are also quite different ideas about 'equilibrium' in the various existing models.

Than he briefly discussed the possible consequences of the Big Credit Crunch for climate policy. None of the models has a financial sector (exception *McKibben*): too unstable to include, large dependence on rules and perceptions with less inertia than 'real' economy, which makes the two difficult to combine. What to do now? Deficit spending à la *Keynes* may give high inflation. Do we need an adjusted/reconstructed *Keynes*ian vision? *Barker* is pessimistic about prospects given present policies (such as stimulating private investments). But in his view there is a huge opportunity: invest the freed-up resources into decarbonizing the economy *now*.

7. Models at a Glance V: A Multi Agent Model for Emissions Trading

Kendichi Matsumoto

After this, we had a presentation by *Dr. Kendichi Matsumoto* (*Center for Global Environment Research, National Institute for Environmental Studies* (NIES), Tsukuba, Ibaraki, Japan) on the application of multi-agent models for emissions trading analysis. *Matsumoto* argued that a lot of analysis on emissions trading has been done applying top-down approaches (especially CGE) which is to be characterized by a focus on the final results of emissions trading.

But this kind of methodology does not recognize that trade is implemented from day to day. The trade process is important and will influence the final results. Up to now, however, few studies focussed on the process.

The multi-agent model of *Matsumoto* is able to distinguish between agents who participate only in trading emissions rights (not necessary to abate emissions), agents with emissions abatement targets, and different kinds of speculative agents: random, trend, anti-trend, day-trade etc. In essence, it tries to understand how the use of emission trading systems (ETS) by speculators may affect the carbon trade price while using an evaluation of an artificial market approach (CCX).

One result of the model is that if no penalties exist against agents who do not (cannot) achieve the emissions abatement targets, the targets will not be achieved. Therefore, a fine (as a kind of penalty) might be an important motivation for the agents to achieve the targets. This leads to the question of how the emissions abatement level, trade values, trade price, trade frequency, etc. wil be influenced by the fine. The model shows that as the fine becomes higher, emissions trading is activated and violation of emissions abatement targets is reduced.

In his concluding remarks *Matsumoto* argued for more research in this area. Special attention should be given to the refinement of the emissions trading system, improvement of agents' decision making and learning methods (e.g. determination of bid price and amount, self-abatement). An introduction of laws and/or institutions related to emissions trading (e.g. safety valve, penalties, JI/CDM) would be nessecary, and a connection with other markets and the entire economy (from partial to general) seemd to be very useful.

One interesting point in the following discussion was the question whether trading is inherently unstable and whether trading could be regulated in order to make it stable, or whether regulation with e.g. a fixed carbon tax is the only proper way towards stable emission reduction pathways.

8. Models at a Glance VI: Dynamic Coupling of the Climate, Socio-Economic Systems and Ethics & Policy

Michael Ghil

The next presentation was by *Prof. Michael Ghil* (*Ecole Normale Supérieure* (ENS) Paris, France). “It is easy to predict, what is hard is to trust the prediction” set the tone.

He argued in favor of fluctuating between toy models and detailed ‘realistic’ models. He showed a huge Earth System Science diagram in which humans are only one small rectangle - *Bretherton*’s horrendogram from 1986. In one of his papers he made an interesting attempt to assess uncertainties of GCMs by increasing degrees of stochasticity on parameters (cf. *Bart Strengers*).

He then presented the work on the NEDyM (Non-equilibrium dynamic model) as part of an ongoing EU-project – see *Hallegatte* et al. in the reference list. They make two points: in the economic literature there are two schools explaining business cycle dynamics; one argues it is the result of external shock to the economy, the other favors endogenous dynamic explanations; *Hallegatte* et al. suggest that, like in climate dynamics, it is good to take both explanations seriously. As a consequence, one should extend the discussion on economic damage from climate change (or, generally, catastrophic events) to the question of whether and, if so, how such events interfere with the endogenous dynamics.

In the NEDyM simulations investment flexibility is used as a key control parameter. It is found that the simulated economy shows endogenous bifurcations when the investment flexibility becomes large. It is also shown that for such situation a catastrophic event during the economy’s upswing is more damaging than in periods of slow or zero growth, because in the latter case there are more unused resources available to restore the damage. Quite some questions remain to be researched, e.g. the role of infrastructure role in the energy/transport transition, the coupling of this model with agents/networks a.o.

In the discussion it became clear that there are in fact no or only a few basic underlying (economic) principles of the kind used physics (such as conservation principles) - it is then unclear what is actually parameterized. Indeed, economic models can break conservation principles. According to *Ghil,* economic science is in its infancy, needing a distinction between strong and weak knowledge.

Another point was the “correct” definition of the term “agent” – is it one individual, can it be an institution or even an entity with artificial intelligence? Furthermore, the ethical dimension of climate policy and climate science was touched intensivly. Finally the question was raised, on responsibility resp. the role of science with regard to the question “Success of climate policy”.

9. Models at a Glance VII: MADIAM

Dmitri Kovalevsky

Dr. Dmitri Kovalevsky (*Nansen International Environmental and Remote Sensing Centre* (NIERSC), St. Petersburg, Russia) gave a presentation on MADIAM, which is the acronym of **M**ulti-**A**ctor **D**ynamic **I**ntegrated **A**ssessment **M**odel. It is an attempt by *Weber*, *Hasselmann* a.o. to couple the simple climate model NICCS (**N**on-linear **I**mpulse response **c**oupled **C**arbon cycle-**C**limate **S**ystem) (*Hooss* et al. 2001) to an Multi-Actor Dynamic Economic Model (see *Weber* et al. 2005).

In MADIAM, the most important driver of economic growth is investments in technological change: firms strive to escape the erosion of profits through the pressures of competition (increasing wage levels, diffusion of technological advantages) by continually investing in technology and know how (human capital). Structural unemployment can be represented, it arises when it is more profitable for firms to invest in productivity (technology - with associated reduction in employment and wage costs) than in physical capital.

An important dynamics is the erosion of profits by competition, which then forces entrepreneurs to introduce cost-reducing innovations. The model is said to contain a lot more realistic features than traditional economic equlibrium models. One important general outcome is the fact that there is no unique growth path governed by the “invisible hand”. The economic evolution depends strongly on the market strategies of the individual economic players and already minor modification of consumer and supplier behaviour leads to business cycles.

In the discussion one focus was on the linkage of climate damage and economic actors, especially firms. *Kovalevsky* explained that there is a nonlinear damage increasing with temperature. While the next version of the model is going to provide space-time fields, actually the standard MADIAM version only uses one (the global mean temperature) climate parameter.

Climate damages are measured in the model in money units, which means some empirical parameterization is introduced, and if this element becomes too big, business understands that something should actually be done.

One current opinion was that the rejecting of the standard production function in form of a shift of attention from capital labour substitution to human resources / skilled labour is a highly interesting aspect of MADIAM. With regard to the question "How many actors are needed?" which had been discussed several times during the conference, *Kovalevsky* could imagine a bit more complicated structures with several agents more, indeed, but he nevertheless identified as one key idea of this MADIAM approach to keep the model simple – there always will be a few actors but not thousands or even billions.

10. Models at a Glance VIII: The Imaclim-R Model

Renaud Crassous

Finally, *Dr. Renaud Crassous* (CIRED Paris) gave a presentation on the IMACLIM model developed by *Olivier Sassi, Jean-Charles Hourcade, Céline Guivarch* and *Henri Waisman* and the speaker himselfs. *Crassous-Doerfler* started with a survey of the existing "small industry" of energy-economic models where e.g. the numbers of publications increases much quicker than the number of scenarios. On the one hand there surely will always be a model diversity, a situation of a coexisting different models: because there is no "ideal" model of the global economy, because of the ongoing controversies on several subjects in economic theory, because of the mask of parameter uncertainties, and because an empiric validation on historical trajectories is not possible in the social sciences including economics. On the other hand *Crassous* constated persistent dissatisfactions with the existing models in mainly three dimensions:

(1) Economic growth - a lot of models are not aible to depict both - short run and long run dynamics - which however is needed.

(2) The space of available techniques – here the development towards hybrid models seems to be a promising way.

(3) Optimality and expectations – developing a model one has to decide between optimization and simulation with advantages and disadvantages on both sides. Following *Muellbauer* the representative agent may produce "an elegant and striking informational economy" (*Muellbauer* 1976). But is this still right when he is infinitely forward looking?

> While expectations are et the heart of the political challenge there is a tendency from rational expectations to perfect expectations, and only few efforts are made to overcome the two poles: “myopic behavior” versus “perfect knowledge of the future”.

According to *Crassous,* the model IMACLIM is to be characterized as a hybrid form which combines static I-O (Input-Output) analysis of an economy (EU) with an economic growth model in the form of a series of dynamically connected equilibria. I-O coefficients are adjusted, partly on the basis of separate models such as an energy model.

There are some interesting results: e.g. the carbon price profile changes completely in comparison with usual models, due to the interactions between inertia, bounded expectations and induced technical change, and there are interesting insights on how the transition towards a low carbon society may be achievable. In this way, a more adequate analysis of structural change in relation to climate policies seems possible.

The discussion was mainly on the possibilities of linking models of the new generation with the existing ones. Another question raised was “taxes versus permitts”, and the question of legitimation the (international) institutions setting the quantities or prices for carbon.

One interesting point concerned different categories of models. Participants agreed that not only models with a high predictive capability are needed, but also models serving as a kind of toy which allows one to play with different hypotheses and investigate their possible implications. Without this sort of mental training it may be hard to come up with the kind of ideas that will be needed to tackle the climate challenge.

III. Conference Programm

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Information for Participants of the: **EXPERT WORKSHOP**

Towards the next generation of climate policy models

Berlin, November 13-14, 2008

Preliminary Agenda

TIME	THURSDAY – 13TH OF NOVEMBER 2008
12:00	Welcome lunch
13:30	Introduction – Prof. Carlo JAEGER
14:30	Models at a glance I: ASTRA - Dr. Wolfgang SCHADE
16:15	Short break
17:00	Models at a glance II: Ventana Systems - Dr. Tom FIDDAMAN / Prof. John STERMAN presentation via WebEx
18:00	Models at a glance III: lagom – Prof. Carlo JAEGER
20:00	Dinner

TIME	FRIDAY – 14TH OF NOVEMBER 2008
9:10	Introduction – Prof. Carlo JAEGER
9:15	Models at a glance IV: E3 models - Dr. Terry BARKER presentation via WebEx
10.10	Models at a glance V: A multi agent model for emissions trading - Dr. Kenichi MATSUMOTO
10:45	Short break
11:00	Dynamic coupling of the climate, socio-economic systems and ethics & policy - Prof. Michael GHIL
12:10	Models at a glance VI: MADIAM – Dr. Dmitry KOVALEVSKY
12:40	Lunch
13:40	Models at a glance VII: The Imaclim-R model - Renaud CRASSOUS
14:15	Conclusion –Prof. Carlo JAEGER
15:00	Coffee and snacks - END OF WORKSHOP

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V. Publications and Websites

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Look at one of the following websites:

www.atmos.ucla.edu/tcd/

www.climateinteraction.org

http://blog.metasd.com

www.european-climate-forum.net