EUCALC

Explore sustainable European futures

Expert consultation on transboundary effects of EU decarbonization pathways

Pre-read document for the workshop

Thursday 22nd November 2018

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730459.

Table of Contents

1 Agenda

Expert consultation on Transboundary Effects of EU decarbonization pathways

Thursday, November 22, 2018 from 10:30 AM to 5:30 PM

"Sun" meeting room | European Climate Foundation (ECF) Building | Rue de la Science 23 | 1040 Brussels

Time	Activity
10:00 – 10.30	**Coffee/tea and registration**
10.30 – 10:45	**Opening & welcome** - *Workshop agenda, objectives, participants introduction* **Prof. Wusheng Yu**, University of Copenhagen **Adrian Taylor**, 4sing (facilitator)
10:45-11:10	**Presentation of the EUCalc project**- *Short overview presentation followed by clarifying questions and brief discussion* **Dr. Jem Woods,** Imperial College London **Garret Patrick Kelly**, SEE Change Net
11:10 – 11:30	**Background to Transboundary module of the EUCalc**- *Short overview presentation on the methodology and assumptions* **Prof. Wusheng Yu and Francesco Clora**, University of Copenhagen
11:30 – 12:45	**Interactive dialogue #1** - *Exploring the most important, relevant and representative user-defined pathways to be simulated in the EUCalc for generating the transboundary effects*
12:45 – 13:45	**Lunch**
13:45 – 15:00	**Interactive dialogue #2** - *Discussing possible modalities for the transboundary effects to be presented in the EUCalc (e.g. as the trade matrix itself or in terms of key indicators)*
15:00– 15:30	**Coffee/tea**
15.30 – 17.15	**Interactive dialogue #3** - *Reflecting on the long run relationship between GDP growth and trade expansion, the size of key parameters such as trade elasticities (e.g. Armington elasticities), the use of differential sectoral productivity growth pattern to generate expected structural changes, the treatment of land and other natural resource supply, and the representation of changing energy technologies in a trade-focused CGE model. Other issues to be discussed include recent setbacks in globalization and global cooperation, their implications on long run trade development and de-carbonization efforts, as well as the EU's future position and role in global trade and global de-carbonization efforts.*
17:15 - 17:30	**Wrap up and closing** - *Summary, key takeaways and next steps*

For additional information please contact: Francesco Clora fc@ifro.ku.dk or Wusheng Yu wusheng@ifro.ku.dk

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement no. 730459

2 About the European Calculator

2.1 What is a Calculator?

The Calculator approach consists of a multi-sectoral systems model associated with a web-tool that allows users to explore the options for reducing GHG emissions from now to 2050, and to see the consequences of these choices on multiple sustainability issues. To this end, users are enabled to control levers[1], expressing behavior, technology or practice patterns among the different sectors, which affects the GHG emission trajectory, and a range of sustainability impacts. The first Calculator was developed in 2009 (UK 2050 Calculator[2]) to enable the UK Government to develop their greenhouse gases (GHG) emission mitigation strategy, namely the UK Carbon Plan. Since then, more than 30 Calculators[3] have been developed worldwide so far, with a few others already in process. These calculators can be used for informing policy making, designing GHG mitigation strategies, reporting on the Intended Nationally Determined Contributions (INDCs), education and research purposes, disseminating knowledge, and contributing to the climate change debate more broadly.

Building on the success of some early national 2050 calculators, the Global Calculator[4] was developed, which was led by the former UK Department of Energy and Climate Change (DECC), and co-funded by Climate-KIC, involving several world leading institutions in the project. The Global Calculator enables users to explore the options for reducing global greenhouse gas (GHG) emissions associated with land, food and energy systems in the period to 2050. The Global Calculator also extends the approach used in the country level 2050 calculators by illustrating the detrimental impacts of climate change associated with global-level choices.

---

[1] Each 'lever' allows for four different 'levels', based on the ambitions in terms of GHG emissions reduction. **Level 1**: Business as usual; it contains sectoral projections aligned and coherent with the observed trends. **Level 2**: Ambitious but achievable; this level is an intermediate scenario, more ambitious than business as usual but not reaching the full potential of available solutions. **Level 3**: Very ambitious but achievable; this level is considered very ambitious but realistic, given the current technology evolutions and the best practices observed in some geographical areas. **Level 4**: Transformational breakthrough; this level is considered as transformational and requires additional breakthrough and efforts such as a very fast market uptake of deep measures, an extended deployment of infrastructures, major technological advances, or strong societal changes, etc.

[2] The original UK 2050 Calculator is available at: http://classic.2050.org.uk

[3] See the full list of completed calculators with links to access them at: www.2050.org.uk/calculators

[4] The Global Calculator is available at: www.globalcalculator.org

2.2What is the European Calculator?

The European Calculator (EUCalc)[5] is an ongoing project supported by the EU Horizon 2020 Programme, which builds on the expertise of these existing calculators. The project is led by PIK-Potsdam (Germany), involving several other European institutions.

The goal of the EUCalc project is to test low-carbon transformation pathways on the European and Member State (MS) scale. This project will develop a novel and transparent open source model combined with a Transition Pathways Explorer, an online tool providing instant results from the EU Calculator model runs.

With EUCalc tool, European and national policy-makers, businesses, NGOs, innovators, and investors will be able to create online and in real-time their own pathways and compare them to other integrated pathways. The results will enable EU policy-makers to support the energy, emissions and resources debate on a low carbon transition.

The development of the EUCalc tool is a module-based process. Each work package of the project produces one or multiple modules that are linked together to form a global model (Fig.1). This allows each module to work independently on its own module.

2.3The role of co-design in EUCalc

EUCalc addresses multi-dimensional and inter-disciplinary issues that requires a wide range of expertise to develop the tool. Decision-support tools are mostly shaped by highly disciplinary and technically deep scientific debates and have often omitted the input of key stakeholders. It is for this reason, that the EUCalc embeds a co-design process with stakeholders and experts, organized through workshops for each main module (Fig. 1). Through this process, stakeholders are involved to shape and calibrate the EUCalc tool by helping co-design the determinants and the scope of the scenarios.

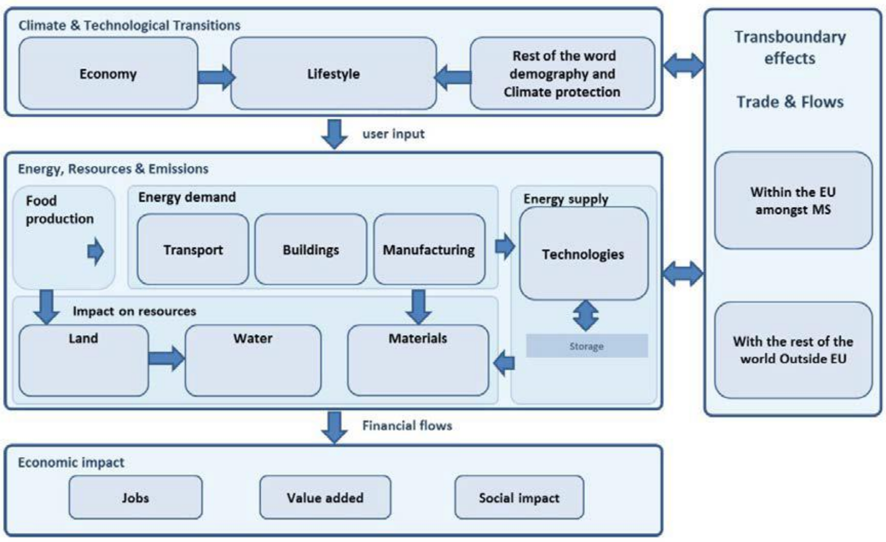

Figure 1 – Modular structure of the European Calculator model

[5] More information on the EUCalc is available on its project's website at: www.european-calculator.eu

3 The transboundary effects module

The University of Copenhagen is leading the work package on Transboundary Effects and Trade flows ("WP7" hereafter) of the EUCalc project, in collaboration with PIK-Potsdam, Imperial College, Climact, Climate Media Factory, T6ECO, SEE-Change and TU Delft.

Within the broader scope of the calculator, the trade WP aims at quantifying the transboundary effects, including intra- and extra-EU trade flows, of EUCalc pathways at sectoral levels as obtained from the other modules using a computable general equilibrium (CGE) modelling framework that simulates perturbations to a projected baseline of the world economy.

3.1Modelling approach

Within the EUCalc project, trans-boundary flows refer to the trade of goods and services amongst the EU MSs, as well as between the EU and the Rest of the World (ROW). As the envisioned de-carbonization pathways impose changes in both energy demand and supply, levels and structures of production and consumptions at sectoral and country levels would also be altered. This in turn would change the internal and external economic dependences concerning the EU MS at sectoral levels and lead to changed trade patterns. Furthermore, as transboundary flows of goods and services also embody energy consumption and GHG emissions, projecting transboundary flows is therefore also an important consideration in evaluating the options and tradeoffs of EU de-carbonization pathways.

Modeling the transboundary effects therefore mandates the use of an economic modeling system that takes into consideration not only inter-sectoral linkages such as the input-output linkages connecting raw materials and fossil fuels to final outputs, but also linkages through the competition/allocation of available economic resource such as labor and capital. Further, EU MSs and the rest of the world must also be connected in the model such that imbalances between demand and supply at sectoral levels for each country can be accounted for via transboundary trade flows. Essentially, this requires the use of a global computable general equilibrium (CGE) model focused on trade linkages. In fact, CGE models are a typical tool for empirical analysis of distributional and welfare impact of different policies (Wing, 2004, Burfisher, 2011). More generally, they can also be used to measure the result of shocks to an economic system (i.e. computable), encompassing simultaneously all economic activities (consumption, production, employment, taxes, savings, trade etc.) and the linkages among them (i.e. general), in an economy where at a given set of prices all agents are satisfied (i.e. equilibrium) (Burfisher, 2011). To analyze the trade and transboundary effects of EUCalc decarbonization pathways, WP7 adopts a modified version of the GTAP-E model (Burniaux and Truong, 2002, McDougall and Golub, 2007), which is the energy-environmental version of the GTAP model (Hertel et al., 1997). The GTAP model is generally considered as a standard CGE model. GTAP's expansive country coverage and its general equilibrium modelling structure on sectoral and trade linkages within and across countries complement the scope of the EUCalc as it allows for simulating the trans-boundary effects of alternative EUCalc pathways under various lever settings.

Substantive research efforts in this WP include:

- Constructing baseline projections based on the GTAP9 database (Aguiar et al., 2016) at its sectoral and country classifications to 2050, to coincide with the 2050 timeline envisioned in other WPs of the EUCalc;
- Modifying the structure of the GTAP-E core model to accommodate the sectoral coverages of other EUCalc WPs, including sectoral energy consumption and emissions;
- Designing an interface to facilitate the transformation of alternative sectoral EUCalc pathways as inputs into the specifically designed GTAP model for simulating the trans-boundary effects;
- And simulating the alternative EUCalc pathways as model scenarios to generate the trans-boundary effects to be included in the EUCalc pathway explorer.

Thus, this WP interacts with WPs 1-5 by using their results and with WP8 by supplying the trans-boundary effects as inputs.

3.2 Baseline projection and implementation

The purpose of the baseline construction is to establish a likely business-as-usual (BAU) scenario towards 2050, against which the transboundary effects of alternative EU decarbonization pathways can be simulated. In Deliverable 7.1 (link), we gathered annual GDP projections and the associated main drivers such as population, labor force (skilled and unskilled), capital stock, and total factor productivities for individual countries including all EU MSs. After surveying several recent model-based projections that can be considered as BAU, i.e. various "reference" scenarios and Shared Socioeconomic Pathway 2 (SSP2)[6] projections, we selected the following sources:

- **GDP**: EU Reference Scenario 2016 (European Commission et al., 2016) and OECD-SSP2 (Dellink et al., 2017);
- **Population**: EUROSTAT, EU 2015 Ageing Report (European Commission (DG ECFIN) and Economic Policy Committee (AWG), 2014, European Commission (DG ECFIN) and Economic Policy Committee (AWG), 2015) and SSP2 projections for IIASA (Kc and Lutz, 2017);
- **Labor force**: EUROSTAT, EconMap2.4 (Fouré and Fontagné, 2016) and EU 2015 Ageing Report (European Commission (DG ECFIN) and Economic Policy Committee (AWG), 2015). Total labor force is divided into skilled and unskilled, drawing from education projections obtained from Fouré and Fontagné (2016), which in turn are gathered from Kc and Lutz (2017);
- **Capital stock**: EconMap2.4 (Fouré and Fontagné, 2016);
- **Total factor productivity** (TFP): EconMap2.4 (Fouré and Fontagné, 2016) and EU 2015 Ageing Report (European Commission (DG ECFIN) and Economic Policy Committee (AWG), 2015).

[6] The Shared Socioeconomic Pathways describe alternative trends in the evolution of society and ecosystems from 2005 to 2100 at the world and regional levels. The SSPs are part of a framework that the climate change research community has adopted to facilitate the analysis of future climate impacts, vulnerabilities, adaptation, and mitigation. In SSP2, the world would undergo a transformation in which social, technological and economic trends do not deviate much from historical patterns observed over the past century.

With these data, we can use the GTAP model to project the world economy from 2011, which is the base year of the GTAP-E 9 database (Aguiar et al., 2016), to the year of 2050. In this projection, we target population and labor force projections during the 2011-2050 period by directly imposing shocks to the correspondent exogenous GTAP variables. To project GDP, we endogenize TFP in order to target the projected GDP levels. Additionally, we endogenize the total capital stock using the "Baldwin equation" (Francois and McDonald, 1996), opting for a fixed savings rate closure with capital accumulation.

In addition to implement the macroeconomic projections, we also target the projected changes in fossil fuel prices (IEA, 2012, IEA, 2017) by endogenizing changes in the productivity of the oil, coal and gas sectors. Finally, we also assume a 2 percentage points differential with respect to the regional TFP between the manufacturing sectors and other sectors.

When implementing the baseline, it is obvious that many other factors may also shape the world economy and the way the world economy is interconnected in the long term. For instance, different CGE modelling groups apply different approaches with respect to sectoral productivity differentials, trade openness and trade costs, aggregate land and natural resource supply, long term income elasticities, and linkages between the economy and the environment. All these considerations may have non-trivial implications on the structure of the projected baseline.

With respect to ***inter-sectoral productivity differences***, we follow an approach similar to the one suggested in Fouré and Fontagné (2018) and LINKAGE (Van der Mensbrugghe, 2005). The two studies assume 2 percentage points additional productivity change in manufacturing with respect to services and use exogenously defined TFP for agriculture. In our projection exercise, we assume the manufacturing sectors' TFP to be 2 percentage points higher than the average regional TFP. Other studies, such as the WTO World Trade Report 2018 (WTO, 2018a), estimate econometrically these productivity differentials with respect to the average TFP in each region, based on databases such as EU KLEMS and OECD-STAN. There are also a few CGE models that use an array of differential sectoral productivities, in particular with respect to the relative TFP growth in agriculture. For example, Robinson et al. (2014) suggest that existing studies indicate that TFP growth in both developed and developing countries is highest in agriculture, followed by manufacturing and services.

In addition to inter-sectoral productivity differences, other major drivers of structural change are ***trends/assumptions on trade policies and globalization and trade-related parameters***.

In long run projections, current or historical ***trade policy trends*** are typically assumed. For example, Fouré and Fontagné (2018) adjust tariffs to their historical trend (2004-2011), using MacMap HS-6 CEPII ITC database. Given the recent setbacks in globalization and global cooperation, one may wonder whether there will be a need to modify our recent assumptions on trade policy trends or whether the recent setbacks are merely a transitory phenomenon that would not be persistent in the time frame of our projection.

Another important issue in long run projection of trade flows rests on the size of the ***trade elasticities***. Thus far, we have been using the Armington elasticities[7] provided in the GTAP9 database. However, given the major structural changes in the world economy, the estimation of correct Armington elasticities is crucial, as the standard ones could lead to unreasonable trade volumes among regions (Schuerenberg-Frosch, 2015). For example, if a sector-specific carbon tax would be implemented, the high elasticity for gas would result in over-traded gas as it has lower emission intensities as compared to other fossil fuels (oil and coal). On the other hand, as EU countries are operating within an integrated market, the opposite argument for higher elasticities for intra-EU trade flows of many other products may be appropriate. Therefore, guidance on adopting appropriate trade elasticities are needed.

The assumptions regarding the ***trade-to-income elasticity*** are also essential for determining the global trade volume in 2050. Fouré and Fontagné (2018) calibrate the trade-to-income elasticity on historical data. However, this elasticity has been falling in recent years relative to its long-run trend (Hukkinen et al., 2016). Since carbon leakages are crucial within the EUCalc, the decision of exogenizing or endogenizing the trade-to-income ratio is of fundamental importance, as it will have a major impact on the final results. In some CGE models, the base assumption is a linear relationship between GDP growth and trade expansion, which nevertheless does not fit well with past observations (WTO, 2018b).

Reductions in ***trade costs*** are also an important factor to take into account, in particular in the light of the importance of trade for the EUCalc. In the last decades, falling trade costs have been observed (OECD and WTO, 2015). Furthermore, the adoption of new transportation technologies and the opening of the Northern Sea Route due to melting ice caps may further reduce transportation costs in the future (Bekkers et al., 2018). Thus, whether or not efficiency gains in the global transportation sectors should be considered becomes a relevant question.

An additional issue that is connected to the expected increase in food demand towards 2050, is about the ***long-run supply of aggregated land***. Currently, in GTAP total land supply is fixed at the regional level. However, rising land rents may cause additional land to be brought under cultivation, even though the price elasticity of land supply is estimated to be very low (Renwick et al., 2013, Philippidis et al., 2017). The finite amount of land (and the impossibility of "producing an extra unit") can be solved by introducing a logistic function for land supply in GTAP, as e.g. in ENVISAGE v10[8] (van der Mensbrugghe, 2018).

[7] Armington elasticity: elasticity of substitution between products of different countries. It is based on the assumption made by Paul Armington in 1969 that products traded internationally are differentiated by country of origin. Therefore, it governs the strength of the relative demand response to relative international prices.

[8] In ENVISAGE v10, the aggregate land supply curve is allowed to have one of four shapes (iso-elastic, logistic, hyperbola, horizontal), as needed by the modeller.

3.3 GTAP-EUCALC model interaction

The GTAP general equilibrium approach differs from the EUCalc modularized approach, in which the lever setting reflects a range of ambition levels expressed by the end-user. The combination of the two adds value to the EUCalc with respect to the current existing Calculators. However, three main challenges arise from their interaction. Firstly, the combination of "bottom-up" engineering approach used by the EUCalc for calculating energy demand/supply and emissions across WP1-5 and the "top-down" approach adopted in the CGE model leads to the suppression of sectoral details when calculating the trade-related results. Secondly, the ambition levels specified in a given user-defined EUCalc pathway will change the levels and structures of the demand and/or supply of the economy, and may lead to pathways that are deemed inconsistent in economic terms. Finally, specific mathematical functional forms employed to characterize the demand, supply and trade behaviors in GTAP (as in most other economic models) also limit the extent to which large changes (e.g. level 3 and 4 which represent 'very high ambition' scenarios) can be imposed on the realized outcomes from a given scenarios/pathways envisioned by users of EUCalc

Following an analysis of several sectoral work packages' modelling work, a conceptual framework for interfacing GTAP and EUCalc has been developed in Deliverable 7.2 (which has been submitted and should be made publicly available soon), written in collaboration with project partners from the Imperial College London.

When the end-user changes a lever setting in EUCalc on the demand side (e.g. changes in travel demand or calorie requirements), this modification will be reflected in GTAP by targeting the private household demand. On the supply side, sectoral outputs (e.g. changes in the number of new vehicles produced) and intermediate use of given commodities in the selected sectors (e.g. changes in the fuel mix for electricity production) will be targeted. In addition to changes in quantities, WP 2-5 will also supply the variations in sectoral productivity and in GHG emissions generated by each individual lever setting.

Individual changes in sectoral productivities will be modelled either as neutral technical changes or as modifications in the capital-intensity of the sector, depending on the inputs from the individual work packages.

Reproducing arbitrary changes to demand or supply quantities according to the lever settings in the sectoral WPs is generally a complex task, both from a conceptual and a practical point of view. At the moment, this is done in GTAP by exogenizing the quantity variable through endogenizing relevant tax instrument. The use of twist parameters [9] to directly manipulate the structure of supply/demand could be more appropriate, as e.g. done in ENVISAGE v10 (van der Mensbrugghe, 2018) for CES functions. Following their work, we plan to introduce these parameters in the production nests in GTAP. On the demand side, similar twister parameters to the CDE demand system have so far not been implemented by GTAP modellers, mainly due to technical difficulties associated with the implicit nature of the underlying utility function. During the workshop, expert opinions may be sought regarding the feasibilities on this.

[9] The rational for introducing a twist parameter is to alter the share parameter in a CES, to target a given change in the ratio of the components, with neutral impacts on the aggregate cost. For example, the target may be a cost-neutral increase in the capital/labor ratio by x%.

Another major challenge in the GTAP-EUCalc interaction is related to the electricity sector. GTAP-E does not currently separate between production technologies, whereas EUCalc does. Thus, in order to modify the share in renewables to measure their economy-wide impact, we envision as a way forward the inclusion of a higher capital-energy substitution in the sector's production tree (lowering its usage of fossil fuels). Alternatively, we may consider the GTAP-Power model and database (Peters, 2016a, Peters, 2016b), which disaggregates the electricity sector into 12 sectors differentiated by technologies: transmission and distribution ('T&D'), seven base load technologies ('NuclearBL', 'CoalBL', 'GasBL', 'HydroBL', 'OilBL', 'WindBL' and 'OtherBL'1), and four peak load technologies ('GasP', 'OilP', 'HydroP', and 'SolarP'). However, the risk in following the GTAP-Power approach is that by further disaggregating the database computational bottlenecks may limit the extent to which a large number of scenarios can be solved.

3.4 Representative de-carbonization scenarios to be simulated

EUCalc will generate billions of "instant" results, given the nearly infinite possibilities of combining its levers. This is not possible in GTAP, which requires precise calibration of the modifications to be imposed in the model and time to simulate the scenarios (depending on the sectoral and regional aggregation and on a set of other parameters, it can take up to hours to compute a solution in GTAP).

Owing to the size and computational complexities of the CGE model to be used, the trade module will focus on simulating the transboundary effects of a subset of the virtually unlimited user-defined decarbonization pathways so as to provide an "envelope" to approximate the full set of user-defined pathways. Deliverable 7.2 lists potential scenarios to be simulated in GTAP.

They can be divided into three categories. The first set will simulate scenarios with identical ambition levels in all sectors and countries (i.e. 4 scenarios deriving from the 4 lever settings). The second set will simulate different ambitions across the sectors, with sectoral ambition levels being kept the same across EU MSs. The third set simulates scenarios with deviations by individual countries from the EU-wide ambition, i.e. each EU MS is assumed to deviate its level settings (uniform across sectors) from the common level setting assumed for all other MSs in the core scenario.

It is possible that not all of these scenarios can be successfully computed, mainly because some particular scenarios (linked to ambition levels set at 3 or 4, i.e. very high ambitions) may represent a drastic departure from the current state of the economic system, which the CGE may not be able to compute. The sectoral and regional aggregations play a fundamental role in obtaining coherent and reliable results from GTAP. For some small MSs, the production and trade matrices in the GTAP database present values that are very close to zero. This increases drastically the risk of incurring in corner solutions, hindering the accuracy or even the solvability of the model.

Considering what have mentioned above, what are ***the most important, relevant and representative user-defined EUCalc pathways/*****scenarios** to be simulated for generating the transboundary effects to be included in EUCalc, particularly concerning the commonalities and deviations of decarbonization ambition levels across MSs and sectors? Are the three sets of scenarios mentioned above the important/relevant ones, and if so, are we too ambitious in planning on simulating all these scenarios? Or are there other important/relevant scenarios that are not included in the three sets of scenarios mentioned above?

3.5 Use of transboundary effect results in the EUCalc Pathways Explorer

A single simulation in GTAP generates a substantial amount of trade-related results which, if not properly presented to the model users, may be difficult to read and use. This would hamper one of the objectives of the EUCalc (i.e. accessibility) and would deprive EUCalc of its uniqueness in the family of Calculators, i.e. computing trade effects arising from different EU decarbonization pathways. Therefore, a practical way to effectively exploit the results derived from GTAP is to further process the results to obtain some indicators that may be meaningful for users and policymakers and are easy to present in the online EUCalc Pathway Explorer.

Acknowledging this, what ***key transboundary effects*** (e.g. intra and extra-EU trade flows) should the model exercises focus on? At what sectoral aggregation level and for which key sectors should such results be presented? How should the transboundary effects be presented in EUCalc (e.g. as the trade matrix itself or in terms of key indicators such as self-sufficiency ratio, trade dependency/exposure index, revealed comparative advantage index, etc.)?

4 Bibliography

AGUIAR, A., NARAYANAN, B. & MCDOUGALL, R. 2016. An Overview of the GTAP 9 Data Base. *Journal of Global Economic Analysis; Vol 1, No 1 (2016),* 1**,** 181-208.

BEKKERS, E., FRANCOIS, J. F. & ROJAS-ROMAGOSA, H. 2018. Melting Ice Caps and the Economic Impact of Opening the Northern Sea Route. *The Economic Journal,* 128**,** 1095-1127.

BURFISHER, M. E. 2011. *Introduction to Computable General Equilibrium Models,* Cambridge, Cambridge University Press.

BURNIAUX, J.-M. & TRUONG, T. 2002. GTAP-E: An Energy-Environmental Version of the GTAP Model. Department of Agricultural Economics, Purdue University, West Lafayette, IN: Global Trade Analysis Project (GTAP).

DELLINK, R., CHATEAU, J., LANZI, E. & MAGNÉ, B. 2017. Long-term economic growth projections in the Shared Socioeconomic Pathways. *Global Environmental Change,* 42**,** 200-214.

EUROPEAN COMMISSION, DG ENERGY, DG CLIMATE ACTION & DG MOBILITY AND TRANSPORT 2016. EU Reference Scenario 2016. Energy, transport and GHG emissions Trends to 2050.

EUROPEAN COMMISSION (DG ECFIN) & ECONOMIC POLICY COMMITTEE (AWG) 2014. The 2015 Ageing Report Underlying Assumptions and Projection Methodologies. *European Economy Report No. 8*.

EUROPEAN COMMISSION (DG ECFIN) & ECONOMIC POLICY COMMITTEE (AWG) 2015. The 2015 Ageing Report Economic and budgetary projections for the 28 EU Member States (2013-2060. *European Economy Report No. 3*.

FOURÉ, J. & FONTAGNÉ, L. 2016. Long term socio-economic scenarios for Representative Concentration Pathways defining alternative CO2 emission trajectories. *CEPII Research Report,* 1.

FOURÉ, J. & FONTAGNÉ, L. 2018. CALIBRATING LONG-TERM TRADE BASELINES IN GENERAL EQUILIBRIUM. Department of Agricultural Economics, Purdue University, West Lafayette, IN: Global Trade Analysis Project (GTAP).

FRANCOIS, J. & MCDONALD, B. 1996. Liberalization and Capital Accumulation in the GTAP Model. Department of Agricultural Economics, Purdue University, West Lafayette, IN: Global Trade Analysis Project (GTAP).

HERTEL, T., POWELL, A., FRISVOLD, G., GEHLHAR, M., GRAY, D., HANSLOW, K., HUFF, K., IANCHOVICHINA, E., KUHN, B., LANCLOS, D. K., MACLAREN, D., MARTIN, W., MCDONALD, B., MCDOUGALL, R., PEARSON, K., PERRONI, C., SWAMINATHAN, P., TSIGAS, M., TYERS, R., WIGLE, R., YANG, Y., YANAGISHIMA, K. & YOUNG, L. M. 1997. *Global Trade Analysis: Modeling and Applications,* Department of Agricultural Economics, Purdue University, West Lafayette, IN, Global Trade Analysis Project (GTAP).

HUKKINEN, J., GÄCHTER, M., FERRARA, L., DIMITROPOULOU, D., KEENEY, M., LODGE, D., DERVIZ, A., BUSSIÈRE, M., CEZAR, R. & MROCZEK, W. 2016. Understanding the weakness in global trade-What is the new normal? : European Central Bank.

IEA 2012. *World Energy Outlook 2012*.

IEA 2017. *Energy Technology Perspectives 2017*.

KC, S. & LUTZ, W. 2017. The human core of the shared socioeconomic pathways: Population scenarios by age, sex and level of education for all countries to 2100. *Global Environmental Change,* 42**,** 181-192.

MCDOUGALL, R. & GOLUB, A. 2007. GTAP-E: A Revised Energy-Environmental Version of the GTAP Model. Department of Agricultural Economics, Purdue University, West Lafayette, IN: Global Trade Analysis Project (GTAP).

OECD & WTO 2015. *Aid for Trade at a Glance 2015: Reducing Trade Costs for Inclusive, Sustainable Growth*.

PETERS, J. C. 2016a. GTAP-E-Power: An Electricity-detailed Economy-wide Model. *2016,* 1**,** 32.

PETERS, J. C. 2016b. The GTAP-Power Data Base: Disaggregating the Electricity Sector in the GTAP Data Base. *2016,* 1**,** 42.

PHILIPPIDIS, G., HELMING, J. & TAEBEAU, A. 2017. Land Supply Elasticities. *In:* UNION, P. O. O. T. E. (ed.) *JRC Technical Reports.*

RENWICK, A., JANSSON, T., VERBURG, P. H., REVOREDO-GIHA, C., BRITZ, W., GOCHT, A. & MCCRACKEN, D. 2013. Policy reform and agricultural land abandonment in the EU. *Land Use Policy,* 30**,** 446-457.

ROBINSON, S., MEIJL, H., WILLENBOCKEL, D., VALIN, H., FUJIMORI, S., MASUI, T., SANDS, R., WISE, M., CALVIN, K., HAVLIK, P., MASON D'CROZ, D., TABEAU, A., KAVALLARI, A., SCHMITZ, C., DIETRICH, J. P. & LAMPE, M. 2014. Comparing supply-side specifications in models of global agriculture and the food system. *Agricultural Economics,* 45**,** 21-35.

SCHUERENBERG-FROSCH, H. 2015. We couldn't care less about Armington elasticities - but should we? A systematic analysis of the influence of Armington elasticity misspecification on model results. Department of Agricultural Economics, Purdue University, West Lafayette, IN: Global Trade Analysis Project (GTAP).

VAN DER MENSBRUGGHE, D. 2005. Linkage technical reference document. *Development Prospects Group, The World Bank*.

VAN DER MENSBRUGGHE, D. 2018. The environmental impact and sustainability applied general equilibrium (ENVISAGE) model, Version 10.01. Center for Global Trade Analysis, Purdue University.

WING, I. S. 2004. Computable general equilibrium models and their use in economy-wide policy analysis. *Technical Note, Joint Program on the Science and Policy of Global Change, MIT*.

WTO 2018a. *World Trade Report 2018 - The future of world trade: How divital technologies are transforming global commerce*.

WTO 2018b. *World Trade Statistical Review 2018*.

5 Practical Information

5.1 Reimbursement Form

Please find attached the Expenses claim forms for non-UCPH staff and a correspondent guide. UCPH will reimburse travel expenses and accommodation related to the workshop.

Completed forms should be sent to Elsebeth Vidø (email: elsebeth@ifro.ku.dk) and cc'd to Francesco Clora (email: fc@ifro.ku.dk).

5.2 Information about venue

Please find attached the venue directions.

6 Information Sheet

In advance of attending the workshop we would like to outline our joint understanding of how the workshop will be conducted and how information from it will be used. We take these issues seriously so please take time to read and understand the following. Please let us know in case of any concern. We will ask you to sign a copy of the consent form (overleaf) at the workshop.

I consent to be participant in the Expert consultation on transboundary effects of EU decarbonization pathways, to co-design a novel climate, energy and resources model under the framework of the EUCalc project, in Brussels, on the 22nd November 2018 based on the principles outlined below.

During this workshop, a group of approx. 15 frontline experts from public, private, civil society sectors and academia will come together to share their perspectives and discuss main trade indicators and economic modelling challenges in the light of the EUCalc. The workshop programme (attached) is designed to stimulate interactive knowledge exchange and we welcome your active participation and contribution to this group effort.

The EUCalc project team assures you that we will only record information that is necessary to address the central purpose of our research. While your name and organization will be acknowledged on the list of participants, your inputs and contribution will not be attributed and will only appear in de-identified form in the publications/reports arising from this research. Anonymity of your input will at all times be safeguarded, except where you have consented or specified otherwise. This principle will be applied effectively on social media sites such as Twitter. Pictures taken at the workshop may be used inside project reports and could be used for the project website (http://www.european-calculator.eu/) and project presentations.

I understand that if at any time during the Workshop I feel unable or unwilling to continue, I am free to leave without negative consequences. That is, my participation in this Workshop is completely voluntary, and I may withdraw from this project at any time.

Co-design is one of the central components of the EUCalc project and we thank you for your willingness to participate. As a benefit of participating we would like to highlight an opportunity to be involved in a significant piece of research, to make connections with other prominent experts and to shape the EUCalc. The EUCalc team is also committed to the continued collaboration and exchange with workshop participants, including opportunities for subsequent feedback and access to early releases of the EUCalc. On the other hand, collected information will be stored internally and managed by the EUCalc partners under strict rules defined to safeguard anonymity of your inputs and alleviate any potential participation burdens such as harm for misuse of your identifiable information.

I have been informed that if I have any questions seeking further clarification or assurances about the ethical issues relating to the project, I am free to contact Francesco Clora (email: fc@ifro.ku.dk) or Prof. Wusheng Yu (email: wusheng@ifro.ku.dk).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 730459

Informed Consent Form

EU CALC - Pathways for a sustainable Europe

Expert consultation on transboundary effects of EU decarbonization pathways

Date: 22nd November 2018

Venue: European Climate Foundation, Brussels

I ……………………………………………………………………………………… agree to participate in Expert consultation on transboundary effects of EU decarbonization pathways.

The purpose of the Workshop has been explained to me in writing.

I am participating voluntarily and understand that I can withdraw from the research project, without repercussions, at any time, before it starts or while I am participating.

I am satisfied that the assurances of responsible and strict data governance, given by the *European Calculator projec*t, will be upheld.

I understand that my name and organizational affiliation will appear as a workshop participant, but that anonymity of participants' contributions will be ensured at each research stage in the project, unless otherwise agreed.

I agree that pictures taken at the workshop may be used inside project reports and could be used for the project website (http://www.european-calculator.eu/) and project presentations.

A copy of the information sheet and (this) signed consent form will be given to the signee.

Signature:…………………………………………………………………………………….

Participant's name:…………………………………………………………………………….

Date:……………………………………………………………………………………………..