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Development of an Integrated Spatio-Economic-Ecological Model Methodology for the Analysis of Sustainability Policy

"ISEEM"

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FINAL REPORT

SUMMARY

DEVELOPMENT OF AN INTEGRATED SPATIO-ECONOMIC-ECOLOGICAL MODEL METHODOLOGY FOR THE ANALYSIS OF SUSTAINABILITY POLICY

"ISEEM"

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The ISEEM model or integrated spatio-economic ecological model is the main result of the ISEEM project, funded by the Federal Science Policy (Belspo). It was executed by a consortium of Transport and Mobility Leuven (TML), the Federal Planning Bureau (FPB), the University of Gent (UGent) and the Facultes Universitaires Saint-Louis (FUSL). The project primarily aimed at gaining more experience into the relatively new field of applied spatial general equilibrium modelling and model construction. It handled the development of methodology, data collection, application of the model in the programming language GAMS and a set of simulations with the model.

This report contains the description of the ISEEM spatial general equilibrium model for Belgium, relates on how the database of the project was constructed and gives the main outcomes of these tests with the model, pointing at weaknesses and strengths of the model. The model methodology was based on an extensive literature review of the present state-of-the-art in economic modelling. This literature review is given in a separate document and can be treated as an annex to the ISEEM report.

The primary target group for this report are mainly other researchers who are themselves involved in economic modelling, policy makers with a sufficient background in economics or other people having a particular interest in economics or economic modelling. The language of the report is quite technical, as is the mathematical formulation and theory behind the model.

The spatio-economic ecological model for Belgium is essentially an extension to the RAEM model for the Netherlands, including a new and more detailed dataset for Belgium, re-estimation of relevant exogenous parameters and adding new elements related to sustainability policy. Most of these elements add up to socio-economic and environmental aspects, but also land use and housing.

The ISEEM model is constructed as a regional model at the provincial level, where regions are linked by interregional trade flows, commuting, other transport trips and migration. The complex interplay of regional and spatial linkages allows the user to model and study clustering of activities and (dis)economies of scale, typically studied in the new economic geography (NEG) literature.

The model distinguishes multiple households in each province. These households are aggregate economic agents that represent the behaviour of a part of the population. Each household type represents one income decile, ordered from the poorest to the richest part of the population. This is important to distinguish the welfare effects of policies on different income groups. It also allows calculating indicators related to inequality and poverty, which can be of importance in a policy context.

Environmental elements are mainly included in the form of emissions of air pollutants. Emissions are dependent both on the input of energy to the sector as the total output of the sector. Besides the obvious CO_2 emissions, we distinguish several other greenhouse gasses such as NO_2, CH_4, SF_6 and several non- greenhouse pollutants such as PM_{10}, NO_x, SO_x, NH_3. Environmental damages from pollution are quantified by multiplying the emissions with an appropriate monetary value, reflecting the relative costs of pollution to society. It was assumed that these effects are fully external to society and do not lead to an increase in health expenditures or a loss in labour force.

The complicated government structure of Belgium is represented in ISEEM, taking into account different types of tax revenues, subsidies, household transfers and intergovernmental transfers. In policy simulations, ISEEM is able to reallocate tax revenues or subsidies to different governments. The model allows incorporating different redistribution mechanisms, for example: via income taxes, social security benefits, household transfers, government consumption, etc..

Land use elements are taken up as a production factor for firms. Land and buildings are modelled as fixed factors; firms can choose to invest more or less in land or buildings, dependent on the relative prices of land and buildings. The model can determine how productive a particular type of land is and how changes in land endowment have influence on regional production. Housing is modelled as contributing to the household welfare, an increase in the housing stock in a particular province, attracts households from other provinces. The housing stock in a province depends on the activities of the construction sector.

The possible applications of ISEEM are vast and allow to make some steps in the direction of a full sustainability analysis of policies. Most applications with the model done thus far were related to transport, as it has its origin in regional economics and transport economics. ISEEM is still especially powerful in respect to these transport aspects, more so if the model can be used in tandem with specific transport economic models.

The range of applications has grown with the new elements incorporated in the model. The integration of air pollution makes it possible to check, besides economic benefits or losses, the effect on the environmental damages of pollutants. The integration of land use and buildings as production factors can be further extended to model land use pressure and building investments. The socio-economic elements give an idea on the welfare impacts of policies on different households.

ISEEM applications to sustainability can range (non-exhaustive list) from the effect of investments in new transport infrastructure on provincial level, to the implementation of a cap and trade emissions permit trading system[1], evaluating the loss of productive land due to industrial pollution or estimation of the welfare effect of introducing an energy tax on all consumption goods. In general, the model can handle any simulation which is related to one of its variables, provided that the simulation is implemented in the form of a monetary value or as a percentage change in initial endowments or costs. If the present set-up of the model is not enough for a particular type of sustainability policy, we assure that the model is flexible enough to handle new extensions or different formulations, provided that these are implemented in a correct way in the model code.

[1] In this type of system an emissions 'target' is set, while at the same time a market for emission permits is opened. This theoretically leads to a reduction of emissions at a minimum of economic costs.

While the model is powerful in respect to simulating policies, it can also suffer from its own complexity. Working with ISEEM requires a trained researcher and a substantive knowledge of (regional) economic modeling. ISEEM outputs a variety of information on its parameters, which can lead to an information overload. There is a (real) danger to interpret the model too much as a 'black box'[2] , as it can be hard to see how a particular effect tends to materialize in the model and if it should be interpreted as an error when it cannot be fully explained.

Another problem with nearly every general equilibrium model is related to the use of its exogenous parameters. Often, econometric estimates for these parameters are not fully available or cannot be easily extrapolated to the model. Model estimation is very dependent then, on calibration and 'educated guesses' during model implementation. While it was planned at first, to make ISEEM a fully empirically estimated model, we were only partially successful. In ISEEM, the econometrical estimation was covered by using econometrical estimates based on HERMES. To use these estimates we changed the structure of production technology. However, HERMES did not include all the inputs we distinguish in ISEEM. So even making use of the econometric estimates, some parameters had to be based on 'guesses' and calibration of the model during sensitivity analysis.

During the modelling process, a decision was made to use a more restricted structure of the model for simulations. Government consumption in most simulations was fixed exogenously, migration effects were not taken up and the dynamic version of the model was not used. All of these model aspects are calibrated and function, but sometimes led to large effects on the price of certain commodities, slowed down the model runs considerably or made the interpretation of results more complicated. The limited time-frame of the project did not allow us to take up these aspects in our simulations.

Data collection and data work took considerable time and effort in the construction of the model. Most of the variables and parameters in ISEEM are determined at the provincial level of Belgium, which requires a huge amount of information. Even then, there are some persistent problems with the regional datasets, especially concerning the regional data on production and income for Brussels and the determination of regional trade flows in goods and services. These issues are treated in detail within the report.

The database consists of a set of Excel files, of which the social accounting matrixes at national and at regional level are the most important ones. The national level social accounting matrix was produced based on public data from the Eurostat website, the regional level social accounting matrices were produced based on regional input-output coefficients and data delivered by the National Bank of Belgium. The calibration of interregional trade flows is a part of the model code and is based on the initial freight flows between provinces.

The other files contain the necessary data to enrich the model with other elements, necessary for the treatment of sustainability issues and enabling a richer and more detailed analysis. Specific files for shopping trips, commuting, migration, environmental pollution, land use, labour market, etc. are included and are a part of the publicly available database of ISEEM. While the

[2] The inputs are known and the results are available, but the process in which the results are generated is unclear.

work on the data was extensive, we feel that the dataset can be further improved into different aspects. For example, with respect to social data and data on land use and building stock, regional economic data such as the income in Brussels and domestic savings, regional trade flows in services.

Our policy simulations with the model made use of indicators, to make the analysis of the model results more straightforward. Indicators are split up by the 3 'pillars' of sustainability analysis, mainly: the Economic, Environmental and Social indicators. Economic indicators include domestic production, consumption, inflation and unemployment. Environmental indicators are based on pollution damages and land use by different sectors. Social indicators are based on the household utility and relative distances between the earnings of different households; this includes poverty and inequality of income.

The policy simulations treated in the report try to work out and test different aspects of the ISEEM model. Environmental modelling is treated in a NO_x policy scenario. Labour market issues and the the Pissarides-approach to unemployment modelling is analysed in a commuting cost scenario. Transport costs and transport economic modelling at the regional level are tested in a freight charge simulation, while in the last scenario the effect of a land tax and a decrease in land supply are compared.

These simulations give a good overview on the possible applications of ISEEM and show the performance of the model in applied modelling. The simulations taken up in the report should be considered as tests for the model. Therefore, we do not claim that the results of these simulations are an exact representation of reality, but show that these offer a constructive way to think about policy and about the results of our model.

The simulations also uncover some aspects in which ISEEM can be further improved and some first steps are taken to propose a slightly modified structure, for example in the case of the commuting cost simulation and the land-based simulations. In the commuting costs scenario an alternative formulation for unemployment modelling is used, which links search costs and marginal productivity of labour more closely together. In the land supply scenario, we show that a fixed exogenous land and buildings supply in combination with a fully clearing land market can entail some problems.

The model tests which are by far the closest to 'real policies' are the NO_x policy scenario and the freight charge simulation. The NO_x scenario was suggested by the follow-up committee, as an interesting policy under discussion, which we simplified to be handled within ISEEM. Besides giving results for a 'small' tax on emissions, this simulation treats different redistribution of tax revenues and treats the possibility of a 'double dividend'.

The freight charge simulation was originally based on a kilometre charging scenario with TREMOVE, which was simplified later on to a freight charge for producers and consumers in Belgium. The simulation gives an idea on the indirect economic costs and external benefits of a freight charge and also suggests a redistribution of tax revenues via the social security contributions of employers. A strong double dividend is generated when this type of redistribution mechanism is implemented. However, it is possible that this strong effect is not entirely realistic and that this partially results from the relative inflexibility of capital in the model. A similar conclusion was made at the end of the NO_x policy scenario.

By no means, we refer to our model as holding the ultimate truth in applied modelling. The field of economic modelling is expanding at an increasing rate and so has our experience grown with the construction of this model. However, we feel that ISEEM offers a genuine progress in the field of economic modelling, certainly in the Belgian context. The model is complex enough to check the applicability of a large variety of different policies. It integrates and calibrates a very complete dataset on regional government income and expenditures, regional production, consumption, labour market issues, taxation, emissions data and data on land use. We think that this model can be used and improved by researchers interested in (regional) general equilibrium modelling and be applied to give more insight into policies concerning sustainability.

To avoid that further work on the model becomes incomprehensive and chaotic, as well as giving the reader more insight into the model, the last chapter of the report offers the template of the model and some basic rules when implementing or changing the model code. This can be used by people with a general interest in how the model works or researchers who want to extend the code or build their own models. We also give some useful tips to debug the model and how to implement code in GAMS.

We sincerely hope that this report and the literature review we produced during the project will lead to follow-up work on ISEEM or related models. For those people not having these ambitions, we hope that the report can inform on the applicability and structure of general equilibrium models.