Informatica e diritto, XXXIX annata, Vol. XXII, 2013, n. 1, pp. 57-74

Legislation, Regulatory Impact Assessment and Simulation

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1. INTRODUCTION

1.1. Overview

This article gives an overview over various possible applications of simulation approaches to legislation. Simulation has been used in legislative processes for several decades, nearly from the time when simulation was first used in the social sciences, particularly in political science. Its main use so far was in assessing the impact of alternative political strategies before new legislation would be set into force. This is why Section 2. of this article first discusses the role of regulatory impact assessment. Sections 3 through 5 are then devoted to a discussion of three of the major approaches to social simulation and their use for impact assessment: static and dynamic microsimulation as well as agent-based simulation. Whereas the two former have a tradition of more than half a century, the latter made its entrance into the repertoire of computational social science only some twenty years ago, although there were several forerunners before the term "agent-based simulation" was coined which used similar techniques.

* The Author is professor emeritus at the Universität Koblenz-Landau (Germany). Section 2. extends the introduction of the earlier paper M. BICKING, K.G. TROITZSCH, M.A. WIMMER, *Regulatory Impact Assessment: Modelling and Simulation to Facilitate Policy Choices*, in Ernst A., Kuhn S. (eds.), "Proceedings of the 3rd World Congress on Social Simulation. Scientific Advances in Understanding Societal Processes and Dynamics - WCSS2010", CD-ROM, Center for Environmental Systems Research, University of Kassel, 2010. Section 5.2. discusses first results of the OCOPOMO project (co-funded by the EU within FP7, contract No. 248128; the European Commission cannot be made liable for any content) directed by Maria Wimmer at the University of Koblenz-Landau. The Author also gratefully remembers the time when he first came into contact with regulatory impact assessment during his membership in the Hamburg state legislature from 1974 till 1978.

1.2. Approaches to Social Simulation

During the long history of applying simulation to social, economic and political phenomena, several simulation approaches have been developed[1]. Some were used to forecast future states of a given target system, others rather had in mind that prediction and forecast should only follow a deep understanding of the system in question and a validation of models used for any kind of prediction. It is a matter of course that even the earliest attempts at forecasting via simulation set up complex models of the respective target systems, but the theory behind them was not in all cases properly validated (perhaps one of the reasons why there is often some skepticism among political decision makers about simulation models). If one follows Zeigler[2] one has to distinguish among three steps of validation: replicative, predictive and structural validation. While replicative validation is satisfied when a dynamic process model replicates data from the past (which can be tested at the time the model is first used), predictive validation can only be performed some time after the use of the model, as one has to wait for the predictions of the model to come true (or not). But even this predictive validation is by no means a guarantee for the structural validity of the model as different models might have predicted the same future state of the target system. We will discuss this issue with several examples of simulation models applied to processes where legislation was involved.

System dynamics and microsimulation are certainly the first among the simulation models used for supporting political decision making as they date back to the 1950s, as the System Dynamics Society and the International Microsimulation Association celebrated the 50th anniversaries of these two approaches in 2007[3]. These two approaches both have their merits in defining and analysing political strategies, but their application areas are entirely different.

[1] N. GILBERT, K.G. TROITZSCH, *Simulation for the Social Scientist*, Maidenhead, Open University Press, 2nd ed., 2005.

[2] B.P. ZEIGLER, *Theory of Modelling and Simulation*, Krieger, Malabar, 1985. Reprint, first published in 1976, New York, Wiley.

[3] These events were documented in B. EBERLEIN, R. OLIVA, J. STERMAN, J. HOMER, R. SPENCER, *Welcome*, in "Proceedings of the 25th International Conference of the System Dynamics Society and 50th Anniversary Celebration", Albany, 2007, p. 1; see also A. ZAIDI, A. HARDING, P. WILLIAMSON, A. GUPTA (eds.), *Celebrating 50 Years of Microsimulation*, Proceedings of the 1st General Conference of the International Microsimulation Association, Vienna, 2007.

System Dynamics describes its target system as one undivided entity with a large number of state variables (levels) and state change variables (rates) which are connected to each other via a number of feedback loops formalising the dynamics of the system as a whole. Perhaps its first application to policy modelling was in Forrester's Urban Dynamics which (among others) was used to "simulate various classical urban-management programs. ... With these a job program for the underemployed can be introduced, underemployment training can be provided, tax expenditures for welfare and education can be subsidized, and a low-cost housing program can generate housing directly for the underemployed category of the population"[4]. All of these urban-management programs are, of course, subject to legislation, and in the foreword to this book, John F. Collins, former mayor of the city of Boston, acknowledges that it "attempts ... to show how the behavior of the actual system might be modified", i.e. as a guidance to legislators' modifications of the system. As for the replicative validity of Forrester's urban dynamics one would certainly concede that the model with its about 20 level equations describing the state and state changes of the system and with its more than 300 parameters yields approximate replications of a stylised urban area over 250 years. But Forrester himself warns against "tak[ing] these results and act[ing] on them without further examination of the underlying assumptions"[5]. And he repeats this warning after a detailed discussion of his model: "Before accepting the implications as a basis for actions, the reader should satisfy himself that the structure adequately represents the urban system and the particular problems with which he is dealing"[6] – which is doubtful at least in one respect: in system dynamics models it is variables such as "underemployed" (number of persons) or "declining industry" (number of productive units) which interact with each other, and not underemployed persons and employing firms.

Microsimulation offers a diametrically opposed approach as here the number of underemployed persons or declining firms would only be an aggregate variable which is calculated at the end of each simulated period from the decisions taken by underemployed persons and employing firms (for a more detailed example see Section 4.2.). Generally speaking, microsimulation starts from a large database of empirical data collected from a large number of

[4] J.W. FORRESTER, *Urban Dynamics*, Cambridge, MIT Press, 1969, p. 51.
[5] *Ivi*, p. 2.
[6] *Ivi*, p. 38.

households or individual persons or enterprises. This database contains all data per entity which are used to calculate its future state or states, and for this calculation two modes are usually used: either there is a predefined (and usually empirically based) probability, e.g. of dying during the next period, of giving birth to a child, or of entering into a job or into another job, where the probability depends on other states of the same entity, e.g. the person's age or education. Or the state changes according to some equation, e.g. of getting older by the length of the next period or of having to pay a certain amount of taxes according to the annual income. Microsimulation comes in mainly two different forms, static and dynamic.

- In the static case, we are not interested in changes of the state of essential attributes of the individual entities but only in the value of a variable such as tax load according to a modified tax law (whereas variables such as age or gross income remain unchanged). In this case there is no reactivity on the side of the individual entity, we only calculate what would have happened if different regulations had been in force instead of the ones valid in reality. We will give an example in Section 3.2.
- In the dynamic case, all characteristics of the individual entities may in principle change, which means that the individual entities may react on changes on the aggregate level, which also means that the composition and structure of the simulated population in terms of age classes, of employment classes etc. changes over time and can be aggregated to descriptions of the whole population for future periods.

The reactivity and thus the realistic modelling of real world human beings, households and enterprises in the dynamic microsimulation models is still restricted. This is one of the reasons why microsimulation is more and more replaced by agent-based simulation models in which the entities are endowed with additional characteristics beyond just reactivity. Among these additional characteristics[7] are autonomy, proactivity, and social ability which endow software agents representing human actors to modify the rules which govern their behaviour, to strive for goals and to have internal models of other agents. Only these additional characteristics allow for a more realistic modelling of the interactions between legislators and citizens. Whereas most agent-based models in the literature are relatively abstract and model

[7] These were first defined by M. WOOLDRIDGE, N.R. JENNINGS, *Intelligent Agents: Theory and Practice*, in "Knowledge Engineering Review", Vol. 10, 1995, n. 2, pp. 115-152; see also N. GILBERT, K.G. TROITZSCH, *op. cit.*, p. 176.

artificial societies to study emergent phenomena arising from microspecifications, e.g. the sugarscape variants[8], the technique of agent-based modelling can also be used to replicate real social systems in an extension to dynamic microsimulation (see Section 4.2. and Section 5.).

Generally speaking, an agent-based simulation model is a piece of software which creates an environment in which autonomous software agents can move, communicate whith each other, interact with the environment and thereby changing it. The software agents themselves are software agents which behave according to rules which are programmed into them, including rules to change rules. Usually they have a memory in which they can store perceptions which they receive from the environment and from other agents. They are programmed with goals which make them act proactively, i.e. even without a particular stimulus from the environment or from other agents (for more details see Section 4.2.), and usually there is an observer agents which reports what is going on in the model to the modeller.

2. A Short History of Regulatory Impact Assessment

The regulatory impact assessment has substantially changed over the last forty years. Although every bill starting a legislative process used to be accompanied with an explanation of what the potential consequences of setting it into force could be, a formalisation of this kind of explanation is only some 50 years old. As a recent OECD document[9] shows, elements of regulatory impact analysis were introduced in many industrialized countries as early as in the 1970s, in Denmark even in 1966. In Germany there were several forerunner systems before the ones mentioned in this document – which concedes this to Germany only from the 1980s, but under the Brandt government in 1969 and 1970 a system of policy planning was established in the chancellor's office, and academic research begun approximately at the same time under the heading of *Gesetzesfolgenabschätzung*, the German word for Regulatory Impact Assessment (RIA)[10]. In its early days RIA just consisted

[8] J.M. Epstein, R. Axtell, *Growing Artificial Societies: Social Science from the Bottom Up*, Cambridge, MIT Press, 1996.

[9] Organisation for Economic Co-operation and Development (OECD), *Regulatory Impact Analysis (RIA) Inventory*, Technical report, Paris, 2004, 29th Session of the Committee, 15-16 April 2004.

[10] Pioneering work in Germany was done by C. Böhret, G. Konzendorf, *Handbuch Gesetzesfolgenabschätzung (GFA). Gesetze, Verordnungen, Verwaltungsvorschriften*, Baden-Baden, Nomos, 2001.

of a preface to a legislative bill which described the aims, cost and benefit of the proposed law, but over time the requirements of RIA became more and more detailed. Simulation as a RIA method is not mentioned in the OECD document as this document is not detailed enough to discuss RIA methods in detail. The RIA documents of some countries, however, mention simulation as a possible (but by no means standard) tool for impact assessment, e.g. the RIA Guidelines in Germany[11], but this is rare[12] although – as Sections 3 and 4 show – simulation has been used for impact assessment for decades.

Much earlier, micro analytic simulation[13] had made its entrance into different issue areas (such as tax and transfer policy) in many countries which aimed at a quantitative forecasting of the consequences of different policy strategies. Qualitative tools for the purpose of foresight and for evaluating alternative scenarios were much less widespread in this early area[14], and if they existed they were far from ICT based – perhaps with the exception of a tool developed for the German chancellor's office under the leadership of Horst Ehmke, then minister in the chancellor's office.[15]. This tool was directed at

[11] We owe them to C. BÖHRET, G. KONZENDORF, *Moderner Staat - Moderne Verwaltung*, Leitfaden zur Gesetzesfolgenabschätzung, Federal Ministry of the Interior, July 2000, http://www.bmi.bund.de/SharedDocs/Downloads/DE/Broschueren/2000/Leitfaden_Gesetzfolgenabschaetzung.pdf.

[12] This shows that simulation is still not a widely accepted tool among impact assessors, but at least it shows that RIA guidelines and other published documents are far from being detailed. It is also worth mentioning that most of the web sources listed at the end of the OECD document are difficult or impossible to find.

[13] G.H. ORCUTT, J. MERZ, H. QUINKE (eds.), *Microanalytic Simulation Models to Support Social and Financial Policy*, Information Research and Resource Reports, Vol. 7, Amsterdam, North-Holland, 1986.

[14] Two early examples were C. BÖHRET, *Entscheidungshilfen für die Regierung*, Opladen, Westdeutscher Verlag, 1970, and C. BÖHRET (ed.), *Simulation innenpolitischer Konflikte*, Opladen, Westdeutscher Verlag, 1972.

[15] Ehmke summarised his experience in H. EHMKE, *Planung im Regierungsbereich - Aufgaben und Widerstände*, in Naschold F., Väth W. (eds.), "Politische Planungssysteme", Opladen, Westdeutscher Verlag, 1973, pp. 311-334. Another member of this cabinet, Volker Hauff, parliamentary state secretary in the Ministry of research and technology, wrote his PhD thesis on the use of computers in social research (V. HAUFF, *Möglichkeiten des Einsatzes programmgesteuerter Datenverarbeitungsanlagen zur Analyse, Manipulation und Archivierung von Daten aus dem Bereich der empirischen Sozialforschung*, Freie Universität Berlin, 1968.) and several articles about the use of simulation models (V. HAUFF, F. LATZELSBERGER, *Simulationsmodelle in der soziologischen forschung*, in Gunzenhäuser R. (ed.), "Nichtnumerische Informationsverarbeitung. Beiträge zur Behandlung nicht-numerischer Probleme mit Hilfe von Digitalrechenanlagen", Wien, Springer-Verlag, 1968, pp. 127-147) and particularly about the use of simulating social systems to analyse political alternatives (V. HAUFF, *Simulation sozialer Systeme und politische Alternativen*, in "Atomzeitalter", 1965, n. 3, pp. 80-84).

generating current overviews of the state of all the projects planned under the Brandt government, but its lifetime was rather restricted. Mainly due to the deficiencies of the ICT systems available in the early 1970s, Ehmke's approach was more or less given up under the subsequent Schmidt government which seems to have returned to more traditional tools of policy planning[16]. But strategic planning and governance prove to be an increasingly challenging task, as the latest financial crisis has shown. The world has become increasingly interconnected, complex, and fast-evolving. Consequently, the effects of individual behaviour and of policy choices are much less predictable. At the same time, the amount of data available to governments to learn from monitoring the socio-economic environment has increased.

A special case of regulatory impact assessment which has a very long tradition in legislative studies is the analysis of the consequences of changes in electoral law. Journals such as "Legislative Studies Quarterly" or "Zeitschrift für Parlamentsfragen"[17] are full of articles discussing alternative voting systems or regulations and their effects on the composition of parliaments and other legislative bodies[18].

3. Static Microsimulation for Regulatory Impact Assessment

3.1. Tax and Transfer Regulations

The oldest and still most frequent use of simulation for legislative purpose is static microsimulation of tax and transfer regulations. In this kind of application the entities subject to simulation are not actually potential tax

[16] The Planning-Programming-Budgeting System of the 1960s in the US had a similar fate, see the December 1966 and the April 1969 issues of the Public Administration Review, e.g. D. Waldo, *Planning-programming-budgeting System Reexamined: Development, Analysis and Criticism*, in "Public Administration Review", Vol. 29, 1969, n. 2, pp. 111-112, and A. Schick, *The Road to PPB: The Stages of Budget Reform*, in "Public Administration Review", Vol. 26, 1966, n. 4, pp. 243-258.

[17] Most recently see S. Martin, *Electoral Institutions, the Personal Vote, and Legislative Organization*, in "Legislative Studies Quarterly", Vol. 36, 2011, n. 3, pp. 339-361; T. Makse, *Strategic Constituency Manipulation in State Legislative redistricting*, in "Legislative Studies Quarterly", Vol. 37, 2012, n. 2, pp. 225-250, and J. Behnke, *Überhangmandate bei der Bundestagswahl 2009. Eine Schätzung mit Simulationen*, in "Zeitschrift für Parlamentsfragen", Vol. 40, 2009, n. 3, pp. 620-636.

[18] Most recently, the composition of Switzerland's Federal Council if its members would be elected directly by the Swiss people was analysed by T. Milic, A. Vatter, R. Bucher, *Volkswahl des Bundesrates. Eine Simulation der Bundesratswahlen durch das Volk auf der Basis der Wahlen in die kantonalen Regierungen*, Technical report, Universität Bern, Institut für Politikwissenschaft, January 2012.

payers but tax declarations (or personal accounts of recipients of transfers instead of these recipients themselves). This is because no behavioural changes are modeled and anticipated in this kind of assessment, users of this kind of microsimulation just want to know what would have happened to tax payers or transfer recipients as well to the state budget or the social security budget if the planned legislation had already been in force during the period for which all information about the state of tax payers or transfer recipients was known.

In the optimal case the national finance authority[19] has a database at its disposal which contains a large representative sample of all tax declarations of one year[20]. Assessing the impact of new tax bills then just consists of applying the proposed new rules to all the tax declarations in the sample and calculating the change in the overall revenue as compared to the results of the tax law currently in force and calculating the changes in the average tax load for certain groups of taxable persons (for instance, singles, married couples with and without children, households in different gross-income classes[21]).

3.2. European and National Legislation on Wine

In the mid-1980s the European Commission adopted a new regulation laying down special provisions relating to quality wines produced in specified regions[22] which obliged the Member States "to fix a yield per hectare for each quality wine produced in specified regions (psr) at different levels depending on the sub-region, local administrative area or part thereof, and the vine variety of varieties from which the grapes used are derived (Art. 11 § 1). When this yield is being fixed, account shall be taken of the yields

[19] Inland Revenue in the UK, *Ministero del Tesoro* in Italy, *Trésor Public* in France, *Ministerium der Finanzen* in Germany, Congressional Budget Office and Office of Managament and Budget in the US, *Agencia Estatal de Administración Tributaria* in Spain.

[20] In Spain for instance this is the "Panel de Declarantes del Instituto de Estudios Fiscales" (see A.F. FERNÁNDEZ, R.G. PÉREZ, *PHOGUE-ECV: ventajas e inconvenientes*, in "I Simposio sobre Reformas Fiscales y Microsimulación", Vigo, 2007) which contained several hundreds of thousands of tax declarations, but was later on replaced by another database.

[21] For examples see N. GILBERT, K.G. TROITZSCH, *op. cit.*, pp. 66-73, or G. REDMOND, H. SUTHERLAND, M. WILSON, *The Arithmetic of Tax and Social Security Reform: A User's Guide to Microsimulation Methods and Analysis*, Cambridge, Cambridge University Press, 1998, Chapter 3.

[22] *Council regulation (EEC) No. 823/87 of 16 March 1987 laying down special provisions relating to quality wines produced in specified regions*, in "Official Journal of the European Commission", L(84), 1987, pp. 59-68.

obtained over the preceding ten years". This obligation in Germany was delegated to the federal states, according to Germany's Basic Law, and it posed a legislative problem for the German federal state of Rhineland-Palatinate[23] whose politicians in charge of viniculture tried to avoid any financial losses on the side of the wine growers due to the quantitative restrictions imposed by the European Commission. So they decided to look for a way to fix the maximum yield for

- all (nine) sub-regions in Rhineland-Palatinate,
- (mainly six) varieties (*Riesling*, *Elbling*, *Müller-Thurgau*, *Silvaner*, *Pinot noir* and others, these aggregated) and
- (four) quality levels (defined in Art. 15 § 2.a of the regulation No. 823/87 – *Qualitätswein b.A.*, *Kabinett*, *Spätlese* and *Auslese*)

such that on an average the wine growers would not suffer from losses due to the rule that any harvest exceeding the maximum yield had either

- to be declassified and marketed at a much lower price or
- carried to the following year if the actual yield was lower then,

which in turn was ruled out in art. 11 § 2 of Regulation No. 823/87.

As a consequence, a static microsimulation model[24] was designed and based on a large sample of wine growers with their actual yields of the years 1983 through 1986, parameterised with different combinations of specific maximum yields for sub-region, variety and quality level. The plausibility of the parameter combinations to be analysed was discussed with stakeholders.

Several of the simulation runs resulted in parameter combinations such that, on an average, wine growers would not suffer from losses. Those whose yield usually exceeds the maximum would have an incentive to prune their vines, those who usually harvest less than the maximum (to obtain higher quality wine) would continue to do so. In the end, on an average the per hectare yield would be reduced and the wine quality raised. It goes without saying that many parameter combinations had similar results such that the final choice may have been more or less arbitrary.

[23] Rhineland-Palatinate grows about two thirds of the German wine production, thus for this federal state the issue was more important than for the neighbouring federal states.

[24] The modelling project carried out by the Institute of Political Science of the University of Koblenz-Landau was funded by the Rhineland-Palatinate Chamber of Agriculture which also organised the data collection from the compulsory reports of the viticultural enterprises. For privacy reasons, all data were deleted shortly after the project ended. The code of the simulation model, too, had to be deleted at the end of the project.

4. Dynamic Microsimulation Supporting Legislation

4.1. Demography and Long-term Welfare Planning

Whereas static microsimulation does not model the behaviour of individuals and thus can only be used for short-term assessment, dynamic microsimulation from its first days used not only "available detailed information about the initial state of microunits such as persons and families" (as does static microsimulation, too), but also "available understanding about the behaviour of entities met in everyday experience"[25]. One can of course discuss whether the understanding derived from everyday experience is sufficient for a valid model of a social process, but beside this everyday experience – perhaps one should talk about stylised facts[26] – statistical material is often available to parameterise state change functions and probabilities. Most dynamic microsimulation models serve the purpose of demographic projection and use transition probabilities to model state changes of modeled individuals, among them, depending on the purpose of the assessment, birth and death, marriage and divorce probabilites, migration probabilities (see Section 4.2.), but also the probabilities of moving elements of the educational sector and between different employments and unemployment. Usually, these transition probabilities are modelled as constant over time, mostly because no information is available why and how these transition probabilities should change over time. Dynamic microsimulation, however, is able to show how, for instance, birth probabilities different between different subpopulations (differential fertility) lead to a changing structure of the whole population such that overall birth rates changes over time even without any changes in the modelled individual behaviour. Thus this technique can unveil hidden heterogeneities and their consequences. This is anyway better than the approach taken by the Study Commission "Demographic Change – Challenges Posed to the Individual and Politics by Our Ageing Society" of

[25] G.H. Orcutt, *Views on Microanalytic Simulation Modeling*, in Orcutt G.H., Merz J., Quinke H. (eds.), "Microanalytic Simulation Models to Support Social and Financial Policy", cit., p. 14.

[26] This term was coined in N. Kaldor, *Capital Accumulation and Economic Growth*, in Lutz F.A., Hague D.C. (eds.), "The Theroy of Capital", London, Macmillan, 1961/1968, pp. 177-222. See also the analysis of this term in B.O. Heine, M. Meyer, O. Strangfeld, *Stylised Facts and the Contribution of Simulation to the Economic Analysis of Budgeting*, in "Journal of Artificial Societies and Social Simulation", Vol. 8, 2005, n. 4, http://jasss.soc.surrey.ac.uk/8/4/4.html.

the German Federal Parliament in the 1990s which just compared different simulations starting from different "plausible" basic assumptions[27].

Although demographic projections do not directly assess legislative decisions they are often used to find out whether a certain aspect of social security measures will be sustainable. A nice example for this is the projection of kinship networks over a period of 65 years, when a German research group, one of the first Targeted Research Projects[28], used dynamic microsimulation to find out how many persons in their retirement age would have younger relatives who could perhaps nurse them when they became needy of help. As persons who would reach retirement age in 2050 were just born at the time of the research done in 1986, it was clear that not only the age structure of the German population had to be projected for a population of which less than one half already lived, but also the future kinship relations of persons who were not even adults at the time when the research was done. The result was that, compared to 1986 when only 9.2 per cent of the population over 60 were without partner and children, this percentage was expected to rise up to 22.3 in 2050, under the (perhaps unrealistic) assumption that death rates, birth rates, marriage and divorce behaviour remain constant at the level of 1982/1983 (data from these two years were used to estimate all these demographic parameters). The author summarised that one could and should expect a drastic decrease of the nursing potential within families[29]. Given that nursing needy old-age persons used to be nursed by their partners or children, relying on in-family nursing had to be considered insufficient in the longer run, thus it seemed necessary to develop other nursing possibilities beside supporting infamily nursing which should be less cost-intensive than current inpatient nursing. Soon after the first results were published in 1990, the Federal Republic of Germany introduced a compulsory long-

[27] SCHLUSSBERICHT DER ENQUÊTE-KOMMISSION, *Demographischer Wandel - Herausforderungen unserer älter werdenden Gesellschaft an den Einzelnen und die Politik*, March 28, 2002, pp. 27-30.

[28] This was the so-called *Sonderforschungsbereich* 3, its results discussed here can be found in H.P. GALLER, *Verwandtschaftsnetzwerke im demographischen Modell - Ergebnisse einer Modellrechnung*, in "Acta Demographica", 1990, n. 1, pp. 63-84, and in H.P. GALLER, *Politikanalyse mit Mikrosimulationsmodellen - die Frankfurter Modelle*, in "Mikroanalytische Grundlagen der Gesellschaftspolitik, Band 1, Ausgewählte Probleme und Lösungsansätze. Ergebnisse aus dem gleichnamigen Sonderforschungsbereich an den Universitäten Frankfurt und Mannheim", Berlin, Akademie-Verlag, 1994, pp. 113-135.

[29] H.P. GALLER, *Politikanalyse mit Mikrosimulationsmodellen - die Frankfurter Modelle*, cit., p. 133.

term care insurance. However, neither the cabinet bill (BT 12/5262, BR 509/93) as of 24 June 1993 nor the bill put forward in the Federal Council by the Länder governed by the SPD (BR 534/91) mentioned these research results explicitly. Perhaps the projection done by the research group was not deemed precise enough to estimate the amount of subsidies necessary in coming years or the contributions to the new insurance system necessary to finance the expenses for needy persons. On the other hand the general trend – decrease of the number of younger persons who could care for their elder needy relatives, changes in the lifestyle and family relationships, increase of the number of one-person households, all of these mentioned in the cabinet bill BT 12/5262, p. 62 – was already obvious without more precise simulation results and taken for granted in the subsequent parliamentary consultations.

The term "dynamic microsimulation" is in a way misleading as the behaviour of the microentities is not actually dynamic: they do not react on the changes in their environment triggered by their own behaviour. In the long-term care insurance example, microunits do not adapt to the results of their behavioural changes – only the macrounit external to the model does by introducing a political measure which is then fine-tuned to meet the needs originating from the results of the changed individual behaviour. Thus, this "dynamic" microsimulation does not get the full dynamics of a society in which human actors change their behaviour when they find out that the consequences of their behaviour are disadvantageous. To cope with this problem, an extension of the classical dynamic microsimulation is necessary, introducing some features of agent-based modelling.

4.2. Urban Planning

The following example[30] extends the dynamic microsimulation approach by introducing a more detailed model of decision making on the level of the microentities when these perceive changes in their environment which are consequences of their own behaviour. The model of urban segregation laid out in Feitosa's thesis models the migration behaviour of households in a

[30] This example is taken from the PhD thesis by F. DA FONSECA FEITOSA, *Urban Segregation as a Complex System. An Agent-based Simulation Approach*, Rheinische Friedrich-Wilhelms Universität, Bonn, 2010, http://hss.ulb.uni-bonn.de/2010/2058/2058.pdf and F. DA FONSECA FEITOSA, Q. BAO LE, P.L.G. VLEK, *Multi-agent Simulator for Urban Segregation (MASUS): A Tool to Explore Alternatives for Promoting Inclusive Cities*, in "Computers, Environment and Urban Systems", 2011, n. 35, pp. 104-115.

city in Southern Brasil (it is these households which are represented by the software agents of this model). Parameters of the model were taken from a large sample survey of some 8,000 households which were asked for their socio-economic status and for some behavioural rules which they would apply to decisions about moving from one housing opportunity to another. From these data, a synthetic sample of some 110,000 households was generated which was quite similar to the overall population of São José dos Campos, and these households, in order to achieve their goal of finding the optimal place where to live, had to make removal decisions in every period of the simulation (a simulation step corresponded to one month, typical simulations run for ten years).

Feitosa's study consisted mainly of three parts (and this should apply to studies like this in any case): model design (describing the microspecification from which a macrophenomenon arises[31]), model validation[32] and use of the model for foresight (which seems justified when the microspecification is based on empirical data and when the replicative validation was satisfactory).

Here, the microspecification describes the decision making process of a household considering a removal to another dwelling with the options: do not move, move to an apartment in the same neighbourhood (which is a parcel of approximately 100x100 meters), move to an apartment in a distant but similar neighbourhood and move to a neighbourhood with features different from the current one. The environment which the agents "live" in and which they have to consider consists of 6,385 of these neighbourhoods, parcels of approximately 100x100 meters. All these (many) options are evaluated for their net utility, and the net utilities are converted into propensities (or, rather, probabilities), and the final decision is made with this probability (such that the best option has the highest probability of being chosen and the worst option has the lowest). The net utility of all these options, of course, depends, among others, on the types of households composing the respective neighbourhood (which is mainly described by the percentages of low-income and high-income households), such that every removal changes the composition of two neighbourhoods.

Replicative validation is done by comparing different segregation indices for the real city and for the simulated city between 1991 and 2000 and finding

[31] J.M. EPSTEIN, R. AXTELL, *op. cit.*, p. XI.

[32] This validation is to be understood typically in the replicative sense of B.P. ZEIGLER, *op. cit.*

that not only agregate indices but also the changes of local segregation are satisfactorily similar between reality and simulation.

In the third step, governmental strategies to avoid segregation are introduced into the model, e.g., giving subsidies to poor households such that they can afford a removal to a more affluent neighbourhood or zoning measures which leads to the erection of affordable but well-equipped flats for poor households in an affluent neighbourhood. The study then compares the influence of these governmental strategies on the long term development of the segregation within the city area and thus gives hints at which results these strategies would have led if they were applied to the real city.

In a way, this approach draws on the early urban dynamics studies mentioned above[33] but with two vital differences. First of all, the urban area is not modelled as an indivisible entity, but it has an extension, and it is subdivided into small parcels with very different properties. This allows for a much more detailed picture of the fate of an urban area (in Forrester's model a quality such as segregation could not be modelled at all). Second, its microspecification is much more detailed, as it is not the population which grows or shrinks but the households (father and mother) which give birth to children, dissolve or are fomed. Thus, results of this kind of agent-based microsimulation models gives much more information than even the dynamic microsimulation models discussed before. But still one has to admit that a different microspecification could have generated very similar macrophenomena.

5. Policy Modelling and Agent-based Modelling

5.1. Participatory Modelling Strategies

The approaches discussed so far aim at modelling the state, state changes and perhaps the behaviour of the subjects to legislation, not at modelling the legislative process itself. The legislative process can be seen as a process of negotiations between different groups within parliament, between parliament and cabinet or administration, in many countries also between the two chambers of parliament, but also between government and society. Thus a multitude of stakeholders agents have to be modelled in order to get hold of at least a part of this complicated process. Perhaps one of the first attempts to model the interactions between (local) government, media and the

[33] J.W. Forrester, *op. cit.*

people dates back to 1963[34]. In this attempt the authors modelled the political process of preparing a community referendum about the fluoridation of drinking water (which was an issue in the United States in the early 1960s). Only during the past two decades new efforts were taken to model these interactions, but in the 1990s and in the past decade numerous studies in participatory modelling appeared[35] some of which also relate to agent-based simulation to role-playing games[36].

One of the most recent approaches to participatory modelling and simulation comes from the current project on Open Collaboration for Policy Modelling (OCOPOMO, see Section 5.2.) which tries to combine collaboration platforms for collecting data about stakeholder goals and action rules with software supporting the definition of "consistent conceptual descriptions (CCD) to inform the formal policy models"[37] into which the former

[34] R.P. ABELSON, A. BERNSTEIN, *A Computer Simulation of Community Referendum Controversies*, in "Public Opinion Quarterly", Vol. 27, 1963, n. 1, pp. 93-122. This seminal paper was reprinted in volume one of N. GILBERT (ed.), *Computational Social Science*, Four-Volume Set, Los Angeles, Sage, 2010.

[35] A selection contains N. BECU, F. BOUSQUET, O. BARRETEAU, P. PEREZ, A. WALKER, *A Methodology for Eliciting and Modelling Stakeholders' Representations with Agent-based Modelling*, in Hales D., Edmonds B., Norling E., Rouchier J. (eds.), "Multi-agent-based simulation III", Proceedings of the 4th International Workshop MABS 2003, Melbourne, Heidelberg, Springer, 2003, pp. 131-148; F. BOUSQUET, O. BARRETEAU, P. D'AQUINO, M. ETIENNE, S. BOISSAU, S. AUBERT, C. LE PAGE, D. BABIN, J.-C. CASTELLA, *Multi-agent Systems and Role Games: Collective Learning Processes for Ecosystem Management*, in "Complexity and Ecosystem Management: The Theory and Practice of Multi-Agent Approaches", Cheltenham, Edward Elgar, 2002, pp. 248-285; T.E. DOWNING, S. MOSS, C. PAHL-WOSTL, *Understanding Climate Policy Using Participatory Agent-based Social Simulation*, in "Proceedings of Multi Agent Based Simulation - MABS", Heidelberg, Springer, 2000, pp. 198-213; D. KOPEVA, M. PENEVA, O. BAQUEIRO, R. FRANIĆ, G. GARROD, B. HAUT-DIDIER, N. IVANOVA, M. JELINEK, M. KONECNA, R. LAPLANA, B. MEYER, M. NJAVRO, M. RALEY, A. SAHRBACHER, N. TURPIN, *Critical Analysis and Assessment of EU Policy on Multifunctional Land Use Activities in Rural Areas*, in "Regional and Business Studies", 2011, n. 3, Suppl. 1, pp. 271-287.

[36] In part of the literature, particularly in law studies, simulation is often meant as gaming simulation – which we do not deal here with except in the case where role-playing games are used for collecting data about stakeholder behaviour as in F. BOUSQUET *et al.*, *op. cit.*

[37] M.A. WIMMER, K. FURDIK, M. BICKING, M. MACH, T. SABOL, P. BUTKA, *Open Collaboration in Policy Development: Concept and Architecture to Integrate Scenario Development and Formal Policy Modelling*, in Charalabidis Y., Koussouris S. (eds.), "Empowering Open and Collaborative Governance. Technologies and Methods for Online Citizen Engagement in Public Policy Making", Heidelberg, Springer, 2012, p. 205.

are more or less automatically transformed to become executable simulation programs.

5.2. Example

One of the first models generated from the OCOPOMO modelling process[38] is the "model of the Košice case study [which] covers the subject of energy policy: electricity and heating. The focus is on three issues, namely energy efficiency, decrease of energy consumption and utilization of renewable energy sources in the Košice Self-Governing Region (KSR)" in Eastern Slovakia. "The main aim of the prototype model is to capture the behaviours of key stakeholders and the process of decision making in the energy domain. The prototype model is designed to combine interrelations between the local environmental as well as spatial determinants, economic conditions and realistic social dynamics ..."[39]. The main stakeholders represented by agents in this model are households (consumers) and enterprises (both consumers and producers of energy, but also producers of equipment and know-how), interest groups advising the former, governments and municipalities each of whom have different stakes at the energy issue and influence the process of political decision making in different manners while interacting with each other and with their natural, socio-political and economic environment. The natural environment represented in this Košice prototype consists of, for instance, the available biomass or water power; the socio-political and economic environment includes, for instance, the price of imported oil, gas and electricity. Household agents (48 of them in the current version), for instance, "can either buy a new (additional) heating technology, insulate the house/flat, or decrease the room temperature"[40], whereas heat

[38] Others are about "a policy of establishing competence centres in order to support the development of industrial clusters within the Campania Region" in Southern Italy, described in S. Moss, R. Meyer, U. Lotzmann, M. Kacprzyk, M. Roszczynska, C. Pizzo, *Scenario, Policy Model and Rule-based Agent Design*, Technical Report Public Deliverable D5.1, FP7 Project OCOPOMO, January 2011, http://www.ocopomo.eu/results/public-deliverables/OCOPOMO_D5-1.pdf/view, pp. 40-41, and one "concerned with housing policy in London. This is a particularly useful case study in that there are a large number of stakeholders including the Greater London Authority and 33 borough councils as well as central government agencies, housing associations and NGOs (*ivi*, p. 9).

[39] *Ivi*, p. 28

[40] U. Lotzmann, M. Wimmer, *Provenance and Traceability in Agent-based Policy Simulation*, in Geril P. (ed.), "Proceedings of the 26th European Simulation and Modelling Conference - ESM 2012" (Essen, October 22-24, 2012).

producer agents (three of them) can decide among several supply and pricing strategies and a regulatory office agent and a government can set limits to these strategies and offer subsidies to producers and/or consumers. "The simulation shows the change of average room temperatures and the investments in heating technology and insulation over time"[41].

What is common in all of these participatory models (and particularly in the OCOPOMO process models) is the multitude of different kinds of agents (which one would not usually find in the more "classical" agent-based models in social science)[42]. One of the cores of these models is the ability of the software agents to design their behaviour with the help of complex rule and fact bases which include assumptions about the rules and facts applied by other agents of the same or different types. This allows them to anticipate future possible behaviour of other agents and to negotiate among themselves in a manner which reflects at least part of the behaviour among parliamentary groups and other political actors. Another important ingredient of OCOPOMO models is the close link between the formal model written in a declarative logic-based language (DRAMS[43]) and the documentation of the interviews with stakeholders and other documentary material which makes sure that every detail of the formal model can be traced back to its empirical basis and that simulation results can be compared to the evidence base for the simulation model.

6. Conclusion

This overview of actual and possible applications of simulation models to support legislation will have shown that there is a large still not exhausted potential of giving legislators insights into the possible consequences or their actions. In Section 5. we could show that a simulation model of the legislatory process could help to better understand the complex processes going on in parliaments and their environments (cabinet, lobbying groups etc.).

On the other hand it goes without saying that all kinds of simulation are and will be unable to make precise predictions of future states of a complex

[41] U. Lotzmann, M.A. Wimmer, *op. cit.*; for more details see also M.A. Wimmer *et al.*, *op. cit.*

[42] This refers to the sugarscape-like models, see J.M. Epstein, R. Axtell, *op. cit.*

[43] U. Lotzmann, R. Meyer, *A Declarative Rule-based Environment for Agent Modelling Systems*, in "Proceedings of the 7th Conference of the European Social Simulation Association - ESSA 2011", Montpellier, 2011.

systems or to precisely predict the outcomes of planned policies. What is only possible is a foresight in the sense that possible futures can be sketchily described. Which among several paths into possible futures the real system will take remains unpredictable – even if probabilities can be given for the alternative paths. The responsibility for the measures taken by policy makers remains with these, but simulation can improve the informations on which political decisions rest.