Explorative Visualization of Impact Analysis for Policy Modeling by Bonding Open Government and Simulation Data

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Abstract. Problem identification and solution finding are major challenges in policy modeling. Statistical indicator-data build the foundation for most of the required analysis work. In particular finding effective and efficient policies that solve an existing political problem is critical, since the forecast validation of the effectiveness is quite difficult. Simulation technologies can help to identify optimal policies for solutions, but nowadays many of such simulators are standalone technologies. In this paper we introduce a new visualization approach to enable the coupling of statistical indicator data from Open Government Data sources with simulators and especially simulation result data with the goal to provide an enhanced impact analysis for political analysts and decision makers. This allows, amongst others a more intuitive and effective way of solution finding.

Keywords: Information visualization · Visual analysis · Impact analysis · Simulation · Open Government Data · Policy modeling · Decision making

1 Introduction

One main factor for decision making in the domain of political policy modeling are data. The less data are available, the more challenging is the identification of the problem and therewith the solution finding. Currently most problems are identified based on statistical data, which are often called “indicator data”, since data about a certain issue is measured all the time. Commonly a selected number of indicators are of special interest for decision makers. These indicators are called “key performance indicators” (KPI). Their changes are seriously observed and analyzed to identify expected or even not expected impacts. If a problem is identified, the analysis starts to retrieve the reasons for the underlying problem. Policy options are then worked out that aim to solve the identified problem.

S. Yamamoto (Ed.): HIMI 2015, Part I, LNCS 9172, pp. 34–45, 2015.
DOI: 10.1007/978-3-319-20612-7_4

In particular this solution finding is a challenging task in the policy modeling process, thus it is difficult to predict the most effective policy option for a certain problem. Obviously, decision makers and also analysts have a foundational and sufficient knowledge and expertise, but the problem context can be quite complex and solution finding can be complex and difficult too. This is due to the fact that multiple actions and repeated tasks are required for the decision making and problem solving process. A support for decision makers is the involvement of experts with the special expertise, but the involvement of experts can be cost intensive. An alternative technology is simulation, which allows simulating the impacts of possible policy options [1, 2]. The quality of such a simulator can be good enough, as far as the defined simulation model is well designed.

There exist already a number of simulators and also well-defined models for a variety of scenarios. Unfortunately most of these simulators are standalone software solutions and commonly not well integrated in the policy making lifecycle and in the analysis environment of the stakeholders. This increases the barrier to consider them within the analysis work with statistical indicator visualization solutions, due to their usage complexity.

We introduce in this paper an approach that combines visualization of statistical indicator data with the visualization of simulation data to provide an enhanced impact analysis. Therefore, we first introduce the general aspects and requirements of policy modeling and the policy making process, followed by an introduction of the usage of statistics in form of indicator statistics and simulation in policy modelling. Here, we also explain the benefits of Open Government Data bases, e.g. EuroStat that allows also the broader audience to perform analysis based on real political indicator data. Based on this reflection, we describe our main contribution, an approach to bond the indicator statistic visualizations with the simulation and in particular the simulation result visualizations to provide an enhanced impact analysis for analysts and decision makers. The concept is applied practically by bonding the statistic visualization based the EuroStat's data and the simulator system, which allows to simulate and generate results for a number of topics. The major benefit of this bonding approach is the explorative character in the elaboration of solution options where both, the statistics as is and the expected impact of a policy option can be shown and visualized simultaneously. This may lead to a more effective and efficient policy making, especially for local governments in municipalities, which do not have the budget to involve specific domain experts for almost all kinds of requisite policy decisions.

2 Analysis and Simulation in the Policy Modeling Lifecycle

The policy modeling lifecycle is an abstract term, which summarizes all necessary steps for a successful policy creation. The analysis phase becomes more important with the upcoming integration of ICT that allows in particular an interaction in graphical user-interfaces and is therefore easier to use. Likewise the visualization of political data benefit from the graphical representation, because complex aspect can be identified easier in visual charts than in large data tables. The inclusion of simulation in the policy domain is a relatively new approach, which allows predicting the impact and usage of policies based on mathematical models [25].

2.1 Policies and Policy Modeling Processes

The term policy is defined as "a theoretical or technical instrument that is formulated to solve specific problems affecting, directly or indirectly, societies across different periods of times and geographical spaces" [3]. In public and political context it can result in a new or changed law. In perspective of the creation of policies, policy modeling can be defined as "an academic or empirical research work, that is supported by the use of different theories as well as quantitative or qualitative models and techniques, to analytically evaluate the past (causes) and future (effects) of any policy on society, anywhere and anytime" [3]. So the major focus lays on the policy and the causes and effects on the society. The creation of policies consists of a number of tasks and involves a variety of stakeholders. To bring them in an efficient and effective order, policy modeling can be understood as a process, where it is defined what actor has what task at what certain time. This arrangement of task and stakeholders in relation to the development of policies is commonly named as policy modeling process.

The work in public authorities is majorly defined by concrete (administrative) processes. This should ensure an efficient and effective work. Conventional processes as they are defined in existing works [4–6, 28], are using ICT and new technologies in a more conservative manner. Modern processes with focus on the general alignment of ICT using majorly an abstract policy-making process, e.g. [7, 8, 28]. Most of these process definitions include a gap in bringing together the detailed policy definition and inclusion of ICT within the policy making process. This gap and thereby the solution is addressed in a couple of research projects, among others, in the European research project ePolicy (http://epolicy-project.eu) and FUPOL (http://fupol.eu). In FUPOL there already exists a detailed policy process definition [9, 10]. To each process step a number of ICT features are aligned. The process orients on conventional process definitions and were just enhanced for the inclusion of ICT, which should enable an easier installment in public authorities.

2.2 The Analysis Phase

Policy analysis can be defined according to Weimer and Vining [11, 12] as "policy analysis is client-oriented advice relevant to public decisions and informed by social values." There exist also other definitions that are similar to Weimer and Vinning, e.g. the definition by Gormley [13] or Meltsner [14]. The major goal of the analysis phase in the policy modeling life-cycle is the gathering of an understanding about an existing issue and the identification of possible solutions. The analysis is one of the most significant steps in the policy making where solution options are defined for the followed decision making.

Today established solution finding strategies in public authorities majorly focus on objective data, which are in most cases statistical indicator data. However, also modern

ICT features are going to be established in policy making, for instance the use of social media analysis. In contrast to objective (valid) data, social media data are subjective data, which represent only e.g. certain citizens' opinions. On the other hand these formulated opinions comprise alternative problems and solutions. Overall, the question in the analysis phase is not what kind of data is used; the question is what data is useful to identify the problem, the reason and what can be the best solution.

2.3 Open Government Data and Simulation Data

In most public authorities, the use of statistical indicator data is the common way to identify political problems. To provide an improved transparency, many governmental entities on national or communal level have initiated Open Government Data (sometimes also shortened as Open Data) initiatives where they provide the existing statistical indicator data to the public. Von Lucke [15] defines Open Government Data as open available data sets, which are of interest for public authorities and citizens without any limitation in its free use, redistribution and further use, and which are made available for free (Open-Access). The Open Knowledge Foundation mentions as a general requirement the provision of such data for free – also for commercial usage, and provides them in an open format, e.g. in CSV [16]. For this purpose the data needs to be open-accessible through a portal where the indicators are available in a simple statistical format, such as CSV, or in another open standardized format, such as SDMX (see [17, 18]). Some portals also provide basic visualization techniques to present the data in a graphical form too.

The creation of effective policies depends not only on the included data that is analyzed. It also depends on how identified solution options will be validated and "tested" before they will be ratified and applied. Normally decision-makers judging about the best option based on their experience. In particular local authorities in cities performing decisions based on experiences, especially because it would be too cost intensive to involve experts for each (also simple) problem. Only in complex topics they involve expertise and experts from the corresponding domain or they involve simulation techniques to determine the optimal (empirical) solution option.

The inclusion of simulation, based on mathematical models, allows testing the impact of a solution option under defined conditions as foresight. This does not guarantee any success of a new policy, since the simulation is only a mathematical prediction based on a mathematical model that covers only a limited number of conditions from the reality. However, the simulation is often a useful feature to avoid most useless or too ineffective policies, if the simulator is well designed and the used mathematical model is appropriate for the applied scenario.

Today a variety of simulators for different topics are available. Most of them are only available as very specific solution and using therefore a macro level model. These models are oftentimes precise, but they require high effort to define the conditions for the model. Complementary to these macro level simulators there is another group of simulator, the general simulators, which using a very basically mathematical model to calculate the forecast. These general models cover only the past indicator developments and a small number of dependencies to other indicators. The precision is often not that precise as macro level simulators, but these general models can be easily applied to other topics and used as very flexible impact analysis tools. The major benefit is their easy applicability to many other topics with less effort. However, the available simulators do rarely make use of involving Open Government Data in simulators, which would make it easier for analyst and decision makers to analyze a problem. A better inclusion of Open Government Data sources in simulators would allow a much easier simulation process, since the most actual date will be automatically included for the simulation purpose. In fact, simulation could be better involved for most of decision making processes so that it becomes more or less common to simulate first, before decisions were made.

3 Concept for Explorative Impact Analysis Visualizations

In the following part, we describe our approach of bonding the Open Government Data visualizations with the simulation data visualizations to enable an advanced explorative analysis.

3.1 Open Government Data as Major Data Foundation

The design of a statistics visualization dashboard that should include various types of static visualizations, consisting of two-, three, and multidimensional visualizations, needs to introduce the complexity to gather information from the data. Hereby we have to deal with existing Open Government Data portals and how this data can be used in these two- to multidimensional visualizations.

Existing Open Government Data portals, e.g. EuroStat, DEstatis, Data.gov and Da-ta.gov.uk, mostly structure the data into hierarchies of topics. For each topic a couple of so-called indicators are aligned. Furthermore, each indicator is defined by [26]:

- The name of the indicator, e.g. GDP, public growth, or public density.
- An assignment to a geographical region, i.e. a country, state/province, municipality, or city.
- A time-based data table, which consist of the indicator value by the measured time.
- Optional additional meta-information about the indicator, such as a description of influencing indicators or the used unit.

The introduced structure enables to model the given data in a technical manner by considering also their multidimensional characteristics for designing adequate statistics visualizations. Additionally, the data model needs to support interactive approaches, such as the option to link visualizations and to allow a further exploration of the data.

To allow an effective analysis, the personal orchestration of different visualizations is a beneficial approach. We entitle this visualization orchestration ability “cockpit” as described in our previous works [24, 26]. In general, the terms “cockpit” and “dashboard” [22, 23] are synonymously used, but we prefer the term cockpit, which focuses more on an active use in a very complex environment. For this purpose, the cockpit

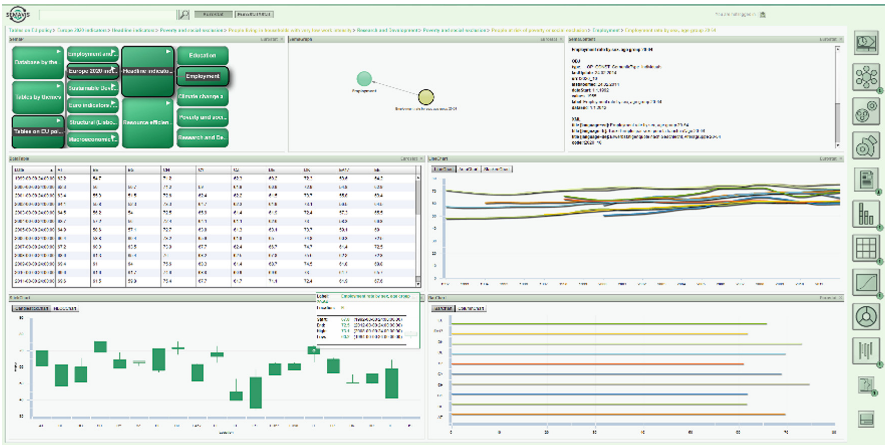

Fig. 1. Visualization of Open Government Data – here an indicator from EuroStat is shown

provides a higher degree of interaction and opportunities to orchestrate a personalized cockpit so that a given task can be solved more efficient (Fig. 1).

As a general design we consider a list of data sources, i.e. EuroStat and some local country and municipality data. The user can switch between these data sources. Next to the database options, the user can also search for one or more indicators that should be visualized. The user can compose his preferred cockpit by a number of available visualizations (simple chart visualization, as well as complex visualizations like Parallel Coordinates), which he can select and deselect. Any visualization can be configured in detail, e.g. decoupling the visualization for a comparative view. In order to focus on the most relevant visualization, the user can also resize the visualizations as needed.

3.2 The Simulator and the Simulation Data

The uses of simulators allow generating a forecast based on mathematical models [19–21, 25]. In perspective of policy modeling simulation is an effective method to test policy options before they will ratified and implemented to ensure its effectiveness (as far as possible with mathematical and therefore theoretical models). The challenge in visualizing simulations depends on its various parts that need to be combined. On the one hand we have the (mathematical) model that represents the simulation scenario based on the real world behavior. Based on this model a simulator must be used that allows generating the forecast based on given initial data and parameters. On the other hand we have the analyst and decision makers as users of these systems. To allow an interpretation of the performed simulation, visualizations are required that allow an intuitive and interactive exploration of the simulation results.

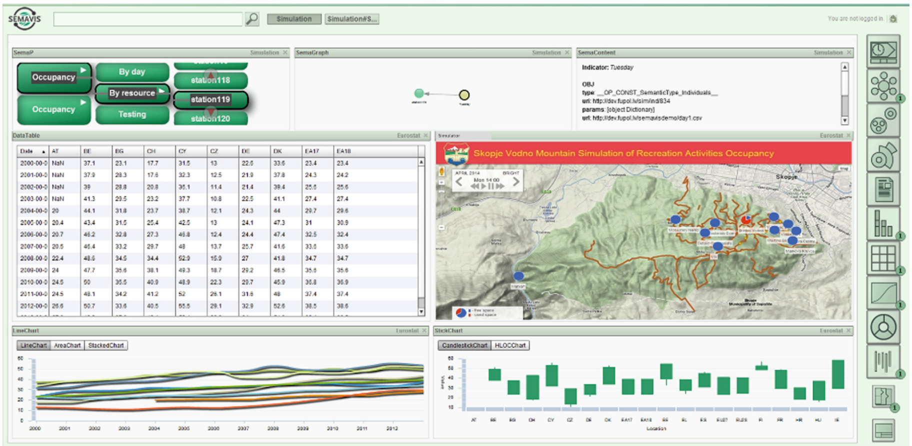

Fig. 2. Visualization of the Vodno Mountain Simulator [21]

From an abstract point of view the challenge of visualizing simulation is similar to default statistical indicator data. Therefore, similar approaches as also used for e.g. Open Government Data are appropriate. Also for this kind of data an explorative visualization based on a dashboard approach is beneficial (see Fig. 2).

In regards of simulation it is important to consider the best fitting kind of simulator. For the simulation of certain aspect a macro level simulator is used, which considers a number of relevant dependencies and influencing factors (Fig. 2 shows the visualization of macro-level simulation results). Such simulators are commonly very precise, but the definition of the models of such a simulator is difficult. Even more, such macro level simulators are only appropriate for the designed simulation scenario. In our approach we consider -in general- both kinds of simulators. For both kinds of simulators the inclusion of Open Government Data is useful, since the retrieval of the context is either beneficial.

3.3 Explorative Analysis and Impact Analysis Visualizations

The major aspect of our concept is the merging of Open Government Data visualization and simulation data visualization (Fig. 3). Especially through the inclusion of concrete indicator data coming from an Open Government Data source for the next simulation phase. Overall we can classify the benefits based on the different stages during policy modelling:

1. At the beginning of the policy modeling process, during the agenda setting, this merge supports to discover problems more precisely. During agenda setting phase decision makers aim to find problems based on negative indicator changes, e.g. the employment rate breaks down. Through the integration of simulation, it can be checked if this has major impacts also for the next time period, or if it is just a small incident around the normal trend.

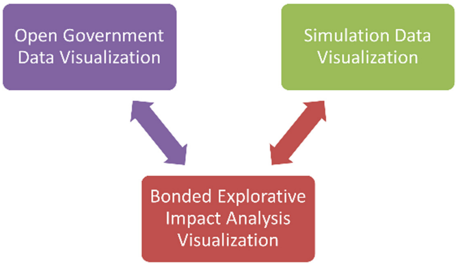

Fig. 3. The abstracted concept for the explorative impact analysis visualization that bonds the Open Government Data visualization with the simulation data visualizations.

2. During the analysis phase (where it is known that an indicator change is getting to be a problem) it can help to understand the context, why this is getting a problem. Even more it supports to allow testing of policy options based on parameter changes or testing of policies that aim to affect related/depending indicators, which in turn will solve the original problem and indicator.
3. During decision making, these combinations are also helpful, hence decision makers are able to trace and retrace the problem and solution finding process. This can be necessary since decision makers have experiences which can vary from the calculated simulation result. Even more political aspects, e.g. the agenda and program of the decision-makers/politicians party, can be included and if the consideration could increase the policy option impact.
4. But also after a policy was ratified and implemented it can be used for evaluation or monitoring purposes. Based on updated indicator data it can be validated if the policy has that impact as it was predicted. Even more, further impacts can be simulated for the next periods, which allow checking, if the policy solves the problem completely or if further investigations are necessary.

We can distinguish the benefit of this merge of Open Government Data visualizations and simulation data visualizations into (1) the enhanced exploration abilities through the parallel visualization of indicator data from Open Government Data sources and the simulation results. This allows the retrieval of the entire context of a current political problem as well as the forecast prediction. Another advantage (2) is the testing and elaboration of a planned policy. Thereby the parameters of the simulator will be adapted or a depending indicator can be changed in regards of the expected policy impact. Afterwards the simulation allows to predict the overall impact and if the aimed problem solution will be successful (in theory).

To enable the bonding of Open Government Data and simulation data visualizations, the indicator data from an Open Government Data will build the baseline. Based on a selected indicator the simulation will be performed. Afterwards the results of both data can be analyzed based on a cockpit approach where the user is able to select his preferred kind of data and visualizations.

4 Implementation of Explorative Impact Analysis Visualizations

The implementation follows the explained concept. In a first phase we considered the Open Government Data visualization based on EuroStat. EuroStat provides a large number of statistical indicators about countries and regions of Europe. The EuroStat indicator data building the baseline for the followed simulation, based on policy modeling simulators. The combined integration (technically and visually) builds the explorative impact analysis cockpit.

4.1 Open Government Data from EuroStat

In our approach we use EuroStat as Open Government Data source, because it covers the indicator data about all European countries and regions. EuroStat provides three technical features [26]: (1) it comprises a hierarchy of the available indicators, which allows users an easy exploration through the existing indicators. (2) It provides metadata about the included indicator data, e.g. date of update, information about the measurements and dependencies to other indicators. (3) Further it provides the indicator data for all European countries.

The technical inclusion follows the Open Government Data in SDMX[1] format. First of all we considered the available indicator hierarchy internally as semantic structure. Categories are internally represented as concepts and the concrete indicators are represented as instances. Such a network is beneficial for users, since the exploration through such networks is able with semantics visualizations.

The statistical data are also very similar to the provided data. We defined an internal data model that organizes the values and properties in indicator objects, which have as property the label/name, the geographic location and the data timetable (see detailed description in [26]). These data can then be shown in any kind of statistical visualization.

The meta-information is used to enhance and complete the internal representation either the indicator structure as well the statistical representation. In particular information to depending indicators can be considered in the structure visualization. Even more information about existing grouping capabilities can be considered, as e.g. the grouping in age groups or by gender.

4.2 Policy Modeling Simulators

For the visualization and inclusion of the simulators [19–21, 25] and the simulation result data, we adapted the used data models for Open Government Data to those simulator aspects [21]. For this purpose we specified a generic simulator API, over which the communication will be handled.

[1] More information about the SDMX format on: http://sdmx.org (accessed on 16/01/2015).

For the simulation result visualization we considered first of all a data structure, which is similar to EuroStat. The structure should allow an interactive elaboration of the concrete available result-set. Also the visualizations of concrete result indicators are similar handled as for EuroStat data. If the user selects a result indicator, the results will be shown.

The major benefit of the similar integration of simulation visualizations is the coherent use and visualization of the static data. This increases the usability for the users and enables the user both, the elaboration through the EuroStat data and parallel through the simulation result data. Another advantage is the further possibility to merge both kinds of data to a single visualization, where the forecast data of the simulation can be added to existing indicator data (of present and past).

In our current implementation we only include macro-level simulators and focus on the parallel visualization of the indicator from EuroStat and the result data from the simulator. In future we expect to include also the more generic simulators, which would allow providing simulation for most available EuroStat indicators.

4.3 Impact Analysis Cockpit

The combination of both is our so called impact analysis cockpit, where analyst and decision makers are able to analyze the indicator data and perform simulations to generate a forecast and compare the results with the indicator data. This enables analysts and decision makers to elaborate policies based on the current situation (past and present) and proposed situation (target/future). Figure 4 shows the result of the impact analysis cockpit.

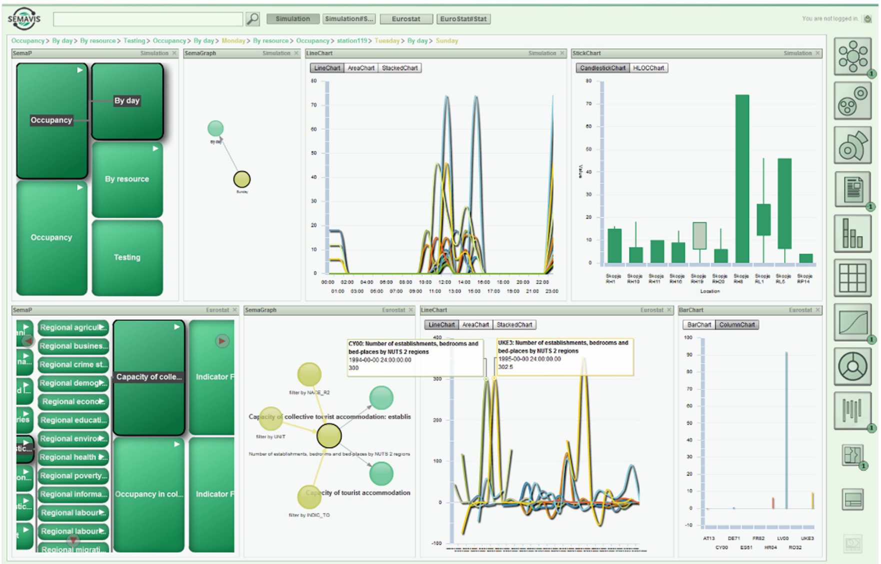

Fig. 4. The Impact Analysis Cockpit that bonds the EuroStat data and the simulation data for an enhanced and more interactive analysis.

5 Conclusion

In this paper we described a new approach to bond the visualization of statistical indicator data with the visualization of simulation data to provide an enhanced impact analysis for policy modeling. This enables analyst and decision makers an easier and explorative analysis of political problems for finding better solution options. The bonding of statistical indicator data and simulation data visualizations allows an effective policy making, since many options can be easily tested towards their impacts and thus allow identifying the (probabilistic/mathematical) best solution for an existing problem. As future work it can be interesting to merge it with other kind of data too, e.g. with Linked-Open Data [27].

Acknowledgment. Part of this work has been carried out within the FUPOL project, funded by the European Union under the grant agreement no. 287119 of the 7th Framework Programme. This work is majorly based on the SemaVis technology developed by Fraunhofer IGD (http://www.semavis.net). SemaVis provides an adaptive and modular approach for visualizing heterogeneous data for various users.

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