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The role of multidirectional temporal analysis in scenario planning exercises and Planning Support Systems

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ABSTRACT

Planning Support Systems (PSSs) have advanced the process of scenario planning by anticipating potential future outcomes to specific scenario stimulus or investment choices. The models used in these PSSs have typically been restricted to forward-looking exercises, limiting the depth and breadth of understanding of particular problem sets. In this paper we argue that PSS-based scenario planning processes and outcomes might be improved by including multi-directional temporal analysis. This includes alternative timeline navigation methods such as backcasting, recasting, and pastcasting, along with traditional (forward looking) forecasting. These methods can greatly improve the general understanding of modeled results by providing an ability to more deeply inspect the potential consequences of proposed scenarios. We demonstrate these benefits using an application of University of Illinois' Land-use Evolution and impact Assessment Model (LEAM) in McHenry County, IL. In this study, multi-directional techniques were used to analyze the results of LEAM simulation scenarios in terms of actual county spatial and population distributions. Possible issues of variable co-linearity and error attribution were addressed along with a method for improving explanatory power through parameter shrinkage. Based on analysis, we discuss how the ability to navigate through timelines can augment scenario planning processes and help guide strategic sustainable development.

1. Introduction

Planning practitioners are constantly challenged with anticipating the potential consequences of proposed policy and investment choices. This is a difficult task. In fact, examples abound of urban planning problems that have resulted from the unintended consequences of seemingly reasonable urban development policies (Bristol, 1991; Deal & Schunk, 2004; Deal & Pallathucheril, 2009a). Some of these problems can partly be addressed with the use of what Michael Batty described as "geo-information-technology based instruments" (Batty, 1995, p.574). More commonly known as Planning Support Systems (PSSs) (see Brail & Klostermann, 2001; Geertman & Stillwell, 2004). Planning Support Systems have generally been found to be useful in support of scenario planning processes (Pallathucheril & Deal, 2007; Geertman & Stillwell, 2012). To this point in time however, PSSs have primarily utilized future-looking land-use change models to project and compare scenario outcomes. They have not yet widely embraced other temporal directional analysis methods that can enhance and inform additional aspects of scenario planning and help minimize unintended outcomes.

Forecasting PSS urban modeling and simulation techniques have typically focused on expanding external model drivers to a wide(r) range of factors or including a broader range of spatial scales in order to compare scenario outcomes (Monticino et al., 2006). Hubacek and Sun (2001) conduct forward-looking simulations on Chinese land-use scenarios based on changes in economic activity and societal interactions. Packaged PSSs (*What If?* and others) typically embrace a real-world simulation mechanism that creates scenarios through a process of user specification of external drivers, usually represented by a suitability of development designation (Klosterman, 1999; Waddell, 2002; Petit, 2005). Verburg and Overmars (2009) simulate scenarios of a future European land-use under a wide range of local and global conditions. Their work assumes that casting a wider (scenario) net will lead to an improved understanding of the future condition. Couclelis (2005) concurs, arguing that PSSs should interface a broad range of qualitative and quantitative scenario models to help future oriented activities in planning. In general, our review of the literature suggests that when scholars analyze the time sequence constructions of multi-scenario simulation analysis, they commonly run forward-looking models. We contend, however, that PSSs that focus only on future forecasts lose

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several important opportunities: to learn from the past, to create scenarios that envision major shifts from current established structures, and an ability to understand *how* to attain future goals or outcomes effectively.

We argue that in order to help planners and decision makers avoid the unintended consequence of policy decisions, a PSS should do more than forecast into the future. We suggest that a good PSS should also have the ability to: a) *recast* from a point in time in the past to the current condition; b) *pastcast* from the current condition to a point in time in the past; and c) *backcast* from a point in time in the future back to the current condition (see Fig. 1). PSS-based scenario planning processes and outcomes will be improved by including the ability to do these multi-directional temporal analyses.

In this paper, we explore the benefits of multi-directional analysis by analyzing various scenario simulations using the Land-use Evolution and impact Assessment Model (LEAM) as part of a larger PSS that was developed for McHenry County, IL. LEAM simulations were used in a county-wide comprehensive planning process to help determine the spatial and population distributions of future development given various policy investments. The process culminated in the publication of a 2030 comprehensive plan in 2010 (McHenry County RPC, 2010). We use the McHenry example to examine the following questions:

1) What are the potential benefits of multi-directional timeline and scenario analysis compared with traditional forecasting techniques?
2) Can a method for performing multi-directional timelines and scenario analysis be usefully constructed and applied? For example, how do we interpret the comparison between simulated results to actual land-use development patterns?
3) What are some of the potential confounding issues in conducting such analysis and how might they be resolved?

We address these questions first, through a more detailed discussion on multi-directional analysis, its potential benefits, and its connection to the existing literature. We then outline a method for doing this type of analysis within an existing PSS and test its usefulness by applying the methods to a previous planning process and PSS application. We discuss how *backcasting* methods were applied in the scenario development process in the comprehensive planning process in McHenry County Illinois. We also present a *recasting* exercise from past county spatial population and development distributions to what were current conditions (in this case 2010). We compare spatial population distributions simulated in different scenario conditions to actual distributions as reported in block group level census data in 2010. This helps us measure the potential impacts of each scenario on planning decisions made in the county over the recast period. Finally, we conclude our analysis by exploring its strengths and weaknesses and by suggesting improvements and potential future work.

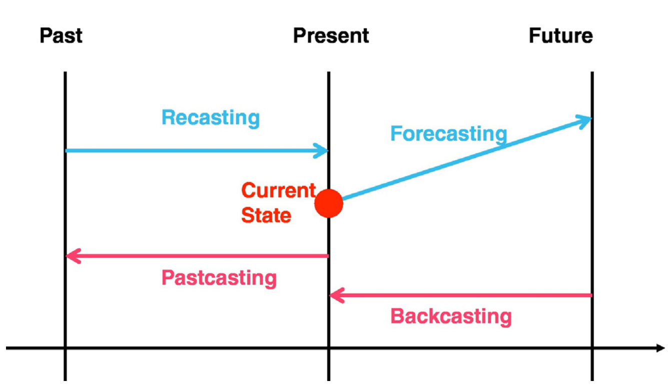

Fig. 1. Multi-Directional Analysis using forecasting, backcasting, recasting, and pastcasting to and from the present or current condition. This multidirectional analysis is useful for constructing and understanding robust planning scenarios.

2. Theory: multi directional analysis for scenario planning

The spatial data sets typically used in spatio-temporal planning simulation modeling environments are now available for multiple points in time. This has not always been the case. Until recently, modelers were restricted to just 1 or 2 spatial data points in time from which to construct a coherent model. With dependable, multiple time point data sets, more reliable and in-depth analysis linking the past to the present can now be examined. These examinations can help planners more readily understand scenario plans and scenario planning processes, where they fail(ed) to catch an important causal relationship, or when the plan might fail to achieve its desired effect. In addition, we argue that an ability to make these types of examinations along multiple directions in timeline will also lead to more robust and reliable future forecasts.

We define multi-directional analysis (from an urban planning perspective) as an ability to analyze urban development problems along a temporal timeline in any direction—past or future. This ability enables the analysis of scenario constructions to be made from many different temporal positions (Fig. 1). The terminologies used in this paper to describe this analytical process include: i) *Forecasting*. Currently the most common approach in scenario planning. A typical forecast starts from a (near) current condition and projects to a future state—this usually refers to the land-use changes that might occur over some specified time period. ii) *Backcasting*. The reverse version of forecasting – the model starts from a future state and draws a developmental path back to the current condition. This is useful for plotting a path that responds to "how do we get there" questions. iii) *Recasting*. Basically, recasting is a reconstruction of the present. It uses forecasting techniques that start from a condition set in the past and project to the current state, usually for comparison purposes (from a projected current state to the actual state). This type of analysis is useful for calibration purposes and understanding a previously unforeseen condition that emerges in the present state. iv) *Pastcasting*. This analysis starts from a current time point (again, not necessarily the current state; it may often be a virtual, more preferred 'current' state) and draws a developmental path back to a previous point in time. This approach is useful for understanding the processes that took place (or should have taken place) in order to arrive at the current or virtual state.

As noted, typical PSSs have primarily utilized future-looking forecasting processes to compare scenario outcomes and the approach is well articulated elsewhere in the literature (Deal, 2011; Batty & Xie, 1994; Geertman & Stillwell, 2009). The following is a more detailed description of other proposed temporal directional analysis methods.

2.1. Backcasting from the future

Although scenario planning process usually utilize forecasts, the analysis, modeling methods, and thought processes do not necessarily have to follow that timeline (going forward in time) in order to construct or explain a scenario in useful ways. Backcasting, the process of starting an analysis from a future state and considering the path required to achieve this state, has been found to be an extremely useful process, especially in the sustainable development realm (Vergragt and Quist, 2011).

Holmberg and Karl-Henrik (2000) define backcasting in planning as a process that starts with a desired (sometimes sustainable) outcome and then explores the strategies needed to achieve it. In other words, "what shall we do today (in order) to get to the desired scenario (outcomes)?" The backcasting process always starts with a preferred future scenario, and then opens up a discussion about how this future can be achieved (Vergragt and Quist, 2011; Kok et al., 2011; Robinson et al., 2011; Dreborg, 1996; Shiftan et al., 2003; Robèrt et al., 2002). Backcasting is methodology that is often applied when planning for complex systems (Dreborg, 1996; Robèrt et al., 2002).