Planning Support Systems and Planning Across Scales: Comparing Scenarios Using Multiple Regional Delineations and Projections

Arnab Chakraborty, Sabyasachee Mishra, and Yong Wook Kim

Abstract: Planning support systems (PSS) often employ urban models that simulate and evaluate impacts of plans. Their application to plan making is, however, challenging when issues transcend local jurisdictions and model assumptions are contested by the stakeholders. Neglecting the role of such specifications, especially when they are important and uncertain, can diminish the efficacy of plans. In this paper, we use the principles of scenario analysis to illustrate the impacts of two such important considerations—forecasts and regional boundaries—on model outcomes and related decisions. We use Montgomery County, Maryland, as a case and leverage a model developed for a larger region, i.e., the state of Maryland and vicinity. We develop two sets of scenarios—one where the county (a local government) freely competes with its neighboring jurisdictions for development and another where a higher-level (i.e., a regional or state) agency controls the extent of development that the county can receive. The scenarios are constructed using different specifications for regional boundaries and also results in different amounts of growth in the county—both rare practices in scenario analysis with models. We then compare the outcomes on a set of indicators and draw implications for planning. We conclude with the argument that planning agencies should compare future scenarios not just with different desirability but with different sets of assumptions and regional formulations.

INTRODUCTION

Debates on the value of urban models in metropolitan plan making are not new. Throughout this debate, however, modelers and planners have developed techniques that have improved (1) the predictive abilities of models, (2) the integration of multiple models such as land use and transportation, and (3) the visualization of outputs and the development of useful indicators. These efforts have added to the toolbox and to the value of the tools in assessing and communicating impacts of plans and decisions.

Many classifications of models and modeling approaches have been made (Klosterman 2000, Batty 1994). According to Batty (1994), modeling as a science of planning and modeling as a strategic tool to further cooperation are distinct approaches. While one is driven to better explain the relationships between the components and characteristics of the built environment, the other should facilitate decision making in a public process by illuminating various complexities of urban systems and stakeholder values. In this paper, we focus on the latter by establishing and addressing a gap between modeling and practice.

Much work has been performed in this area, particularly in the development of planning support systems (PSS) that can capture a range of plans and policy specifications, multicriteria decision analysis models that compare outcomes according to stakeholders’ values, and scenario planning approaches that provide a framework for the process. In practice, these approaches are used in combination to generate and compare alternative visions of the future (Chakraborty 2010). From these analyses, often a single desired, or preferred, future is selected. Policies then are developed to help achieve that future (Hopkins and Zapata 2007, Avin and Dembner 2001).

In the case of large regions, implementing resulting policies coherently requires buy-in from a wide variety of stakeholders that can be difficult to achieve and the inability to do so can leave the plans less effective than desired. Moreover, when such unitary plans or policies are based on important and yet uncertain assumptions, their effectiveness can vary a great deal on the actual variations in assumed trends. This limits the achievement of preferred futures because of lack of decision makers’ control on external forces (Chakraborty et al. 2011) and also can produce unintended or undesirable outcomes. Another aspect of the conventional practice to identify and make policies for a preferred future is that it is a useful tool to mobilize community support towards a shared vision. A process oriented to such ideas can bring divergent interests together. While this purpose has merit, it has been argued that given the political nature of plan making, urban models also should be used to illuminate the complexities of urban systems. This includes evaluating the impacts of competing and alternative choices made by different actors and, in turn, providing each stakeholder unique insights into how plans and decisions, under different assumptions and conditions, can affect each stakeholder’s specific interests and the overall regional outcome. A way to advance this purpose, as we argue and demonstrate, is to recognize the role of assumptions and other specifications in the model outcome. We develop alternative scenarios to illustrate how considering different assumptions and model specifications can help identify useful strategies suitable to heterogeneously governed regions. This, we conclude, adds value

1. Actors are the decision makers and stakeholders at city, county, state, and federal levels.
especially to large regions and planning processes with multiple stakeholders.

**Problem Statement:** We posit the following:

When models attempt to address challenges that transcend jurisdictional and other boundaries, specifications can limit the outcome of an analysis, sometimes to the detriment of subsequent decisions and plans. Developing and examining scenarios that represent outcomes of different assumptions and specifications can illuminate these limitations and allow identifying and equipping us with necessary strategies for multiple possible futures. Furthermore, identifying and adopting suitable, and complementary, strategies within the existing fragmented jurisdictional setup can be a better approach for regionally coherent policies than attempting to implement a consensus-based plan for all agencies in the region.

In the next section, we establish the limitations of current approaches to modeling and scenario planning in multistakeholder processes. Then we explain the objective of the paper. In the following section, we discuss our dataset and models and choice of study area. Then we present our analysis and results. We offer some concluding thoughts in the final section.

**THE GAP BETWEEN URBAN MODELING AND PLANNING PRACTICE**

Multiple studies over the years have reviewed and critiqued the role of urban models and PPS in planning practice (see, for example, Klosterman and Brail 2001, Geertman and Stillwell 2003, Geertman 2006, Hopkins and Zapata 2007). In this section, we establish how they wrestle with the complexities of planning practice in large regions, specifically, those surrounding forecasting growth and selecting regional boundaries. We organize the relevant literature into these streams: (1) potential of scenarios to address complexities of plan-making processes; (2) limitations with respect to the use of PPS and (3) their underlying modeling approaches; and (4) spatial planning and the confounding effects of institutional rigidity.

**SCENARIOS, COMPLEXITY, AND PLAN-MAKING PROCESSES**

In the United States, most urban plans are outcomes of strategic decision-making processes involving multiple actors. Planning processes have attempted to engage these actors through evaluation of alternatives that consider a range of choices, interests, and viewpoints. PSS have provided analytical and visual mechanisms to structure these processes. As a framework, evaluation of alternative outcomes of decisions, i.e., scenario analysis, has been central to the practice of plan making (Chakraborty et al. 2011). From a strategic standpoint, scenario analysis has been used to think about multiple facets of the problem simultaneously and as a tool for addressing the uncertain future in light of the limited cognitive and computational capacity of individuals and organizations. In particular, it is a tool that fosters imagination as well as critical thinking about how a future might unfold. Since its pioneering application by the RAND Corporation as epitomized by Kahn (1962), it has been used widely in various disciplines ranging from business to military applications (Van der Heijden 1996).

Smith (2007) argued that scenarios can be used in a number of ways and in the regional planning context should be used mostly as a tool for prioritization, oversight, and conversation. Where a participatory paradigm is important, using scenarios as a means of thinking collectively about what to do in different futures should foster thinking of a contingency nature, i.e., if _____, then _____. Neuman (2007) has discussed how scenario planning can encourage planners to dissolve geographic and conceptual boundaries and consider impacts and solutions that extend beyond them. Avin (2007) suggests that scenarios should inform urban plans by creating a platform for public engagement of various groups. Building on earlier work, Avin articulates a 12-step mechanism that includes constructing possible futures as distinct from desired futures. He suggests that these futures with intervention options will provide a framework to evaluate them. Nevertheless, the case studies that follow these prescriptions of the process do not make clear how these interventions are different and distinct from the forces that are producing uncertain effects and how one should make plans, given these interactions.

In the practice of metropolitan planning, however, the use of scenario planning has been skewed toward formulating an argument for picking a “preferred future” as opposed to the status quo or business as usual (see, e.g., Council of Fresno County Governments 2009), in direct contrast with the contingency framework of scenario planning. Also, as this review will demonstrate, the participatory framework not only should be capable of comparing alternative scenarios, but also should serve other purposes, such as creating plausible alternatives, facilitating questioning institutional rigidities, and creating radical changes in external forces. The PSS used in these approaches also should be able to handle these considerations effectively.

**PLANNING SUPPORT SYSTEMS AND COMPLEXITY**

In metropolitan planning with its interacting temporal and spatial phenomena, it is almost implausible to think about scenarios without resorting to some version of a PSS. Many of these tools offer planners the ability to view complex data, to forecast potential outcomes of decisions and anticipate their implications, and, more recently, to communicate these to the wider public. Despite their promise however, PSS have been largely used to—and designed to—facilitate plan evaluation not plan making (Batty 2004).

This disconnect is evident in many of the critiques of PSS. Avin (2007) warns that they should be used only to aid planning processes and to create a platform for engaging with diverse stakeholders, not to define the process. He adds that indeterminate factors are the key and those most likely to influence future outcomes...
should be included. Such considerations should be generated through the planning process and multiple sets of variables should be tested. In practice, however, the indeterminate factors are often given less than due consideration and usually are externally specified. For example, the Metropolitan Planning Organizations are required to identify the most likely 25-year growth forecasts within their region, evaluate the impacts on the infrastructure, and then plan for them. The processes often are separated and developing specifications are a precursor to, and not a part of, the planning process. At other times, they are arrived at too rapidly or too early in the process and once estimated they are termed “givens.” The given then carry through the rest of the process, in effect solidifying and multiplying the potential for error.

Scenarios analysis literature shows us how to tackle this separation and linearity by using the notions of strategic thinking (van der Heijden 2006). For example, Hopkins and Zapata (2007) suggest that planners should move away from the idea of preferred futures and replace it with analysis of possible futures that incorporate more than the most likely future conditions. Such a move can ensure that a wider set of uncontrollable effects and conditions can be considered (e.g., supraregional factors). They admit that such approaches would need planners to make multiple plans. Another aspect of this is balancing increasing technical sophistication of models with the needs of communicating model outcomes in ways that can facilitate decision making. For example, Batty (2004) has argued that the development of most models has been driven by advancement in GIS and remote-sensing technologies but still are only abstractly related to cities as emergent complex systems. Practical applications for planning processes need to be driven by bottom up–driven concerns. As Batty writes, “[T]echnology interacts with policy in diverse, symbiotic ways which develop tensions that get resolved by changes in culture and context as much as by adaptation of the science behind the technology or the technology itself” (p. 329). Thus “good” models are those that can be adequately adapted to the problems at hand in the local or specific context.

Klosterman (2001) reviewed a specific GIS-based PSS called What if? While he notes the utility of PSS for decision makers seeking to broaden and inform public dialogue, he adds that its effectiveness is ultimately limited by the user-specified assumption. Similarly, Geertman (2006) has suggested that technology often can outpace planners’ capabilities and framing of problems requiring a dynamic interconnected with each informing the other in an adaptive utilization, ultimately dependent on a conceptual framework sensitive to context. The above critiques, and there are many others, suggest that it is critical to recognize the capacities and limitations of PSS and, ultimately, choose an approach that captures the important complexities of the context.

**LAND-USE MODELS IN PLANNING SUPPORT SYSTEMS**

PSS are often at the interface of underlying models and the decision-making processes. The underlying models are characterized by their heterogeneity, hierarchical structuring of urban phenomena, and approaches to deal with exogenous factors. They can be organized into two broad categories: top-down and bottom-up models. Top-down models employ regression, econometric, and statistical approaches that represent system relationships between aggregate variables depicting best fit of the data. Because of its generalized nature, top-down models are useful for revealing relationships in land-use data and for forecasting purposes. On the other hand, bottom-up models such as agent-based or cellular automata models start from a general understanding of the low-level processes and elements and generate aggregate system behavior by simulating the individual entities in the system.

Top-down models often estimate regional growth projection first and then allocate it among the constituent subgeographies. In the United States, this practice is employed to develop metropolitan-level or state-level projections that then are allocated down to the county level and sometimes further down to traffic-analysis zones. Top-down models have been used in management of natural resources (Castella et al. 2007), simulation of system dynamics in multiscale land-use variables (Veldkamp and Fresco 1996, Brown et al. 2000), and a host of other applications (see Hensher and Button 2004). On the other hand, bottom-up approaches can take top-down outputs as given and look at spatial impacts of them. They also have received significant attention in local-level analysis and decision making (for applications, see Landis 1994, Landis and Zhang 1998, Waddell 2002, Deal and Schunk 2004; for reviews, see Hensher and Button 2004, Kim and Hewings 2011). The choice of a particular model depends on many factors, such as the needs of the project, the availability of data, and user discretion. Still, both kinds are needed to some extent in many planning processes and their insularity can be problematic and deserves careful consideration.

**SPATIAL PLANNING AND THE CONFOUNDER EFFECT OF INSTITUTIONAL RIGIDITY**

Finally, because models attempt to imitate real-world phenomena, they can easily duplicate, and perpetuate, some of its limitations. For example, institutional rigidity, an often-discussed barrier to regional planning (Teitz and Barbour 2007), has become a part of how many models specify and test policies. For example, land-use impacts often are tested last and at a locality level. The high likelihood of these impacts to change as regional policies are changed and their interdependence with other regional and local forces often are ignored at the local-level analysis. Though these considerations sometimes simplify decision making, they also can limit our anticipation of potential challenges and opportunities.

To address these challenges, advancing models alone will not be sufficient. To anticipate adequate variety in future conditions and implementation frameworks, planning approaches also will need to encourage and sustain participation. They will have to provide a platform for sharing divergent viewpoints in a pluralistic society and, when combined with evolving tools, help to develop multiple visions for the future that look beyond the traditional
limits of scale, time horizon, and disciplinary and institutional boundaries. The literature provides many examples where attempts have been made to bridge this gap between empowered advocacy and comprehensive rational planning. It does so most often by utilizing technical tools to empower the stakeholders in the planning process through imagining a normative future (Borjeson et al. 2006, Myers and Kitsuse 2000, Porter 1985). These principles have been used worldwide in many planning processes, including the Norwegian Long Term Program (NLTP), Sustainable Seattle, Oregon Shines, Metropolitan Tunis, and Envision Utah (ArKiss 1996, Barbanente et al. 2002, Grow and Matheson 2006, Kissler 1998).

In addition to unstructured deliberation, several other methods can be applied. One approach sensitive to different stakeholder values is multicriteria decision analysis (MCDA). Malczewski (2006) shows how GIS and MCDA allow diverse (but interdependent) decision makers to insert value judgments and receive feedback on their implications, allowing policy makers to highlight trade-offs between alternatives. Innes and Booher (1999) look at the need for consensus-building planning processes to cope with complex adaptive systems. They suggest that such a framework allows for experimentation, building shared meaning, and change.

Still additional considerations may be necessary. For example, metropolitan planning organizations in the United States need to follow a single set of growth projections for transportation planning according to federal requirements for funding. As a result, scenarios (both land use and transportation) have to accommodate one set of projections—no more and no less. Unless these requirements change, such agencies have little choice but to use unitary forecasts. They can, however, attempt to consider the wider interactions with other agencies and interdependencies between land use, transportation, and other systems when arriving at their assumptions.

In summary, much has been written about how planning processes use scenario analysis, PSS, and urban models and how their use may be limited by the nature of approaches and institutional consideration, among others. To overcome the resulting challenges, planners will have to balance the sophistication of their tools with accessibility and nimbleness. We argue that some of these challenges can be addressed by systematically considering complexities such as multiple sets of projects and interregional and intraregional interactions by moving beyond the traditional static definitions of a model region. Scenarios have specific implications for plan making and, as we show next, how they are constructed affect the outcomes and subsequent plan-making considerations. Understanding a broader range of uncertainties, as we will show, can allow for better assessment of varying future challenges and as a result can lead to more effective plans.

ANALYTICAL FRAMEWORK

RESEARCH OBJECTIVE

In this paper, we use the principles of scenario analysis to illustrate the impacts of two such important considerations—forecasts and regional boundaries—on model outcomes and related decisions. We use Montgomery County, Maryland, as a case and leverage a model developed for a larger region, i.e., the state of Maryland and vicinity. We develop two sets of scenarios—one where the county (a local government) freely competes with its neighboring jurisdictions for development and another where a higher-level (i.e., a regional or state) agency controls the extent of development that the county can receive. The scenarios are constructed using different specifications for regional boundaries and also result in different amounts of growth in the county, both rare practices in scenario analysis with models. We then compare the outcomes on a set of indicators and draw implications for planning.

DATA AND METHODS

The models used here have been developed over time by a number of partnering organizations (for details, please see Knaap and Frece 2006, Chakraborty 2010, Mishra et al. 2010, Chakraborty et al. 2011). Our entire modeling area covers the state of Maryland in the United States and some surrounding counties (see Figure 1). One of the purposes of our modeling effort has been to explore alternative futures for the state of Maryland with the intent to identify policies that maximize the likelihood of more desirable future outcomes.

We briefly summarize the modeling framework and methodology in the following section. The framework is of a loosely coupled set of models that work at different scales (national to local), in different areas of specialization, and for different purposes. They interact, however, as shown in Figure 2 and as explained in the following section, and allow us to generate different sets of forecasts, look at their effect on land-use and transportation networks, and assess their impact using a set of governmental services and quality-of-life indicators.

• National econometric model: The national econometric model consists of two submodels: (1) Long Term Inter-Industry Forecasting Tool (LIFT), a macroeconomic input-output model operating at the U.S. national economy level forecasts more than 800 macroeconomic variables that are then fed into (2) State Employment Modeling System (STEMS) to calculate employment and earnings by industry for all 50 states and the District of Columbia. Output from LIFT serves as input to STEMS. Results from the STEMS model then are allocated by region (political boundaries are imprecise predictors of boundaries of labor markets and economic regions) using current proportions of state-level forecasts for each sector. A detailed description of LIFT and STEMS can be found in the literature (McCarthy 1991, INFORUM 2010).

• Regional model: The regional-level model depicts land-use variables at the county level. At the regional level, the
The forecasting approach is based on a near-total reliance on empirically calibrated relationships. The calibrated model involves 40 equations using progressively more inclusive sets of predictors. The allocation model incorporates review of the benchmark forecasts (Hammer 2007).

- Local model: The local model, titled Landuse Evolution and Impact Assessment Model (LEAM), uses a state-change structured gridded surface whose conditions evolve over time, similar to other cellular automata (CA) technologies (Deal and Pallathucheril 2003). The LEAM grid surface is not flat, however, but gains a “hilly” topography based on both physical and socioeconomic constraining factors. It incorporates techniques that calculate a probability to represent the potential of each cell (900 m² or 0.25 acre) to change from one land-use category to another. This probability of change is influenced by local interactions (e.g., the accessibility of the cell to a predetermined characteristic of its neighborhood or an “attractor”), global interactions (e.g., the state of the regional economy), and other causal mechanisms (e.g., social forces). These produce suitability scores that contribute to the grid surface relief and affect subsequent allocation.

For more on LEAM, see www.leam.uiuc.edu/maryland.
Agencies that use models such as those listed previously often work with specific requirements. For example, Metropolitan Planning Organizations (MPOs) use the most likely 25-year employment and household forecasts to test the stresses on travel network. Similarly, local governments updating their land-use plans may use projections from state economic agencies as given to make policies that accommodate that growth or affect it. The purpose of this paper, in part, is to demonstrate that while current approaches are useful for the purposes they serve, additional understanding can be gained by relaxing constrained projections and testing multiple regional extents.

We specify two scenarios—one where the county (local government) freely competes with neighboring jurisdictions and another where the regional/state government controls the extent of development that the locality can receive. For the first scenario, using our econometric model, we generate county-by-county projections, further detailed into various housing and employment categories using our regional model. For the second, we aggregate county-level projections to the state level. We also specify our land-use models at two scales: one at the level of each county and another at the statewide level.

We selected the case of Montgomery County, Maryland, to demonstrate our point. We could have selected any county for our analysis, but Montgomery County was selected for its rich and varied planning history, its large size, and its high projected growth in the county. To develop the first scenario, we run the land-use model only for Montgomery County and use the projections that are generated for Montgomery County alone, without regard for any interaction with neighboring jurisdictions. We argue that this closely represents a state-imposed growth constraint and call it the Constrained-Development Scenario. For the latter, we use the aggregated state-level projections and run the state-level land-use model. We argue that this represents competing behavior among counties for new growth and call it the Competitive-Development Scenario. This scenario forces competition among municipalities for growth without regard to the specific amount of growth projected for each of these jurisdictions by the economic model. From this run, we extract the outcome for Montgomery County and compare it with the stand-alone run for Montgomery County. We compare the outcomes on a few simple indicators. All the models use year 2000 as the base year and are run for every five-year intervals, up to 2030.

### Analysis

The results of model runs are summarized in Table 1. Two sets are household, and employment totals at a county level, for each

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<tr>
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<tbody>
<tr>
<td>HH</td>
<td>Constrained-Development 363,285</td>
<td>Competitive-Development 357,418</td>
<td>Constrained-Development 435,057</td>
<td>Competitive-Development 74,179</td>
</tr>
<tr>
<td></td>
<td>Retail (a) 72,097</td>
<td>72,208</td>
<td>87,268</td>
<td>94,147</td>
</tr>
<tr>
<td>Office (b)</td>
<td>275,831</td>
<td>276,415</td>
<td>333,797</td>
<td>361,792</td>
</tr>
<tr>
<td>Industrial (c)</td>
<td>43,283</td>
<td>43,276</td>
<td>52,391</td>
<td>56,838</td>
</tr>
<tr>
<td>Other (d)</td>
<td>152,268</td>
<td>152,992</td>
<td>184,198</td>
<td>202,266</td>
</tr>
<tr>
<td>Tot. Emp. (a+b+c+d)</td>
<td>543,479</td>
<td>544,891</td>
<td>657,654</td>
<td>715,043</td>
</tr>
</tbody>
</table>

**Figure 3.** Employment growth

**Figure 4.** Household growth
of the two scenarios, Constraint-Development Scenario and Competitive-Development Scenario. These results also were available at a cell level of size 90 m x 90 m. The employment data also is presented by four detail categories—retail, office, industrial, and other. Each scenario run was modeled for two time horizons on year 2000 data: (1) most recent year or 2010 and (2) for the planning horizon 2030. The future year is identified in conformance to the constrained long-range plan for the county and state. The model results show that Montgomery County will receive a higher amount of households and employment in the Competitive-Development Scenario run than in the Constraint-Development Scenario (Table 1). The results suggest that given the flexibility of growth across all counties, and the possibility of moving to a new locality, Montgomery County will attract more households and employment in the Competitive-Development Scenario. This comes at the expense of our counties and happens because of Montgomery County’s higher attractiveness in terms of land-use and accessibility.

The spatial distributions of household and employment growth in these two time periods for both scenarios are shown in Figures 3 and 4, respectively. The polygons in Figure 3 and 4 represent Traffic Analysis Zones (TAZs), showing the numbers estimated from aggregation of the cell-level results.

The new developments in both scenarios for both land-use types happen as expected. The most growth is in areas closer to the urban centers and next to existing modes of transportation. Areas next to transit stations as well as those with a high possibility of redevelopment get a high share of new employment. The overall higher attractiveness and, as a result, the overall higher demand for land, and the location of nearby counties where that new development is getting transferred from can be attributed to the differences seen between the two scenarios.

These differences in total amount and location of new development can be seen in the land-use change indicators. For example, the loss of agriculture and forest land for both model runs are presented in Table 2. As expected, we find the loss to be greater in the Competitive-Development Scenario than in the County-Constraint Scenario. The loss in agriculture and forest land estimation is built into the modeling tools that further uses the land-cover data in the CA-based allocation process. Figure 5 shows the grid-level variations in the scenarios. The grids that are organized according to the amount of new growth received are as follows: (1) higher growth on County-Constraint Scenario, (2) higher growth on the Statewide Scenario, and (3) higher growth under both scenarios. The grid-level results can be used as a tool to visualize differences more specifically.

Table 2. Montgomery County loss of forest and agriculture land (in square meters)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>County Constraint</th>
<th>Statewide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Land</td>
<td>36,620,100</td>
<td>62,677,800</td>
</tr>
<tr>
<td>Agriculture Land</td>
<td>47,279,700</td>
<td>83,268,000</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

Futures are not necessarily given; they also are not necessarily created solely through purposeful action. They are a product of complex interactions of forces that we cannot control as well as decisions we make. Many authors have noted that even the most sophisticated and integrated models are not able to incorporate all variables of interest. Hopkins (2000) explains that numerous urban models have been developed based on different perspectives and theoretical foundations. Some simulate markets for land, housing, and labor, using preferences of households and firms based on past behavior with respect to prices. Still others rely on past probabilities of land conversions and seek an equilibrium solution. Some are dynamic, usually in discrete time intervals in which actions depend on the results of previous time intervals. In this paper, we use a combination of approaches to develop two sets of scenarios—one where a county freely competes with neighboring jurisdictions (Competitive-Development Scenario using a statewide run) and another where the regional/state government controls the extent of development that the locality can receive (Constraint-Development Scenario). The scenarios are constructed using different specifications for regional boundaries and also result in different amounts of growth in the county, both rare practices in scenario analysis with models.

Our analysis has a number of general implications. It shows that assumptions are important and should be carefully chosen. And, if possible, multiple plausible sets of assumptions should be compiled to test the robustness of policies despite variations in assumptions. While similar in concept but different in application, our study also shows that the choice of regional extents at which models are run affects the outcomes. This is important for a number of reasons. While many studies on limitations of local
governance suggest regional coordination as a way to address multiple issues, the scales and composition at which such coordination should happen often is unclear. Metropolitan areas often have been used as appropriate scales for most purposes, but with the evolving literature on other scales (for example, watersheds, megaregions, etc.), care should be taken in understanding how these ideas are used in formulating the study region. Or, more importantly perhaps, care should be taken that critical areas are not excluded from the modeled region.

More specifically, our findings suggest that a state-imposed constraint on Montgomery County might be too low in its magnitude and thus difficult to implement. It also suggests that in the lack of such constraints, higher amounts of undeveloped lands will be lost resulting in different challenges. The detailed location of development also can be used to argue for or against each set of policies. For example, though it is beyond the scope of this study, it is possible to imagine that a fixed development constraint might be difficult to implement without added political compromise that benefits the county in some ways. The presence of such conditions might complicate the outcome and, indeed, can change the cost/benefit equation for an agency choosing whether to support the constrained or the competitive development policies.

Lastly, the scenario analysis proposed in the paper has practical implications in the state of Maryland. One of the examples is the potential residential and commercial land use for the greater Life Science Center (LSC) proposed in Montgomery County. Based on existing, approved, and proposed development, LSC could yield a maximum of 9,012 additional dwelling units to complement a projected total of 52,500 jobs. The resulting ratio of 3.8 jobs per dwelling unit is based on the existing housing in the greater LSC area (MNCPPC 2010). The Maryland Department of Transportation has concerns over such large-scale development for it might lead to insufficient transportation infrastructure to support such mixed land-use development. This is an example of the differences between the vision of the county planners and of the state planners for the future of Montgomery County. Such differences, depending on the outcome of a process, can lead to a range of outcomes, two of which have been modeled in the two scenarios presented in this paper. Recognizing these possibilities are important to the planning process.

Another example is Prince George’s County’s Konterra Town Center, a planned mixed-use regional activity center that will include more than 4,500 residential units and more than 5.5 million square feet of office, retail, and hotel uses to produce more than 10,000 jobs (PGCPD 2009). In contrast to Montgomery County, the state agreed to this development for it supports the construction of Intercounty Connector (ICC), a major east-west access-controlled highway corridor connecting the two North and South Interstates, 95 and 270. The new development will have access to ICC and will, in turn, become more attractive.

These examples illustrate the kind of decision-making conflicts and uncertainties that exist between land-use and transportation planning agencies in a large region. Our results show that considering a wider range of possibilities can provide better tools for those working on these challenges. This includes comparing future scenarios not just with different desirability but with different sets of assumptions and regional formulations.

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