Intergovernmental Dynamics of Transportation Planning: Why Some Towns Attract More Federal Funding Than Others?

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Abstract

This paper explores the dynamics of intergovernmental relations in the distribution of transportation funds from the viewpoint of local governments. We address the following questions: (1) Why some towns attract more federal and state funding than other towns? (2) Are there some balancing and reinforcing feedback loops that influence some towns attracting more funds than others? We addressed these research questions through developing a stakeholder informed system dynamic model with an explicit focus on the intergovernmental influence (exogenous) and local town level technical and financial capacity (endogenous) dynamics. The model is calibrated to two local towns in Vermont. The model simulates two balancing loops (BL) and three reinforcing loops (RL). BL1: As a jurisdiction receives more transportation funds, they are able to meet more of their transportation needs and require fewer funds in the short term. BL2: With more development, there is less capacity to continue to build, so less money is allocated for new development. Three RLs include more money received leading towards more experience and thus greater technical capacity, more technical capacity directing a jurisdiction to more support from the MPO, and more transportation needs requires more transportation funds which ultimately gives a jurisdiction more financial capacity.

Key words: Intergovernmental relations, transportation policy, governance networks, system dynamics modeling, technical capacity, city and regional planning, knowledge management, intergovernmental management

Introduction

The dynamics of intergovernmental relationships have been extensively studied in the context of governance and policy networks (Koliba et al. 2010, Sorensen and Torfing 2005, and Provan and Kenis 2008). Using theories of complex system models of social theories (Miller and Page, 2007) and management (Sterman 2000), system dynamics models have been built for simulating intergovernmental collaboration (Cresswell et al., 2002), budgeting (Grizzle and Pettitjohn, 2002), and information transfer across governmental agencies (Luna-Reyes et al., 2007).

Cresswell et al. (2002) concluded that dynamic modeling of collaboration and knowledge sharing in intergovernmental networks is worthwhile in shedding light on these processes. Luna-Reyes et al. (2007) seconded this sentiment and added that modeling and simulation is a useful tool for theory-building. In transportation planning, simulation models are widely used to predict travel and understand the dynamics between transportation and land use (Waddell 2002), but we are not aware of any system dynamic model that simulates intergovernmental dynamics of transportation planning. The purpose of this paper is to explore systems dynamics as method of explaining intergovernmental relations and to model the funding distribution system in Chittenden County, Vermont to describe the inner workings of the system, identify leverage points and explore potential areas for change.

Intergovernmental relationships can influence the distribution of financial capital for transportation projects (Rich, 1989). Local governments must cooperate with their regional government to receive a higher priority ranking over projects in other jurisdictions. The regional metropolitan planning organizations (MPOs), Regional Planning Commissions (RPCs) and State Departments of Transportation (SDOTs) face a similar competitive structure in that MPOs vie against other MPOs for funding from the state and states compete with other states for federal funding. With multiple levels of government involvement, the capacity of governments to coordinate across these levels of government can influence how the funds are distributed.

Throughout the past few decades, the federal transportation bills in the US incrementally changed the relationships between the levels of government for transportation planning and strengthened the role of regional government. Transportation planning involves multiple levels of government in a network that has a multitude of decision making points. Local, regional, state and federal governments each make choices that affect the planning and distribution process. The dynamics of intergovernmental relationships that were set in 1950s with highway bills changed with passing of the Intermodal Surface Transportation Equity Act (ISTEA) in 1991. The ISTEA reversed the trend of federal control and gave state, local, and regional governments more decision-making authority (Dilger 2010). This new legal framework changed the dynamics of intergovernmental relations and mandated more power to MPOs and RPCs who now had greater responsibilities for managing a diverse set of priorities (Gerber and Gibson 2009). This task, however, proved to be difficult as MPOs and RPCs still had to manage state priorities and federal fiscal power. After ISTEA 1991, next significant change in the intergovernmental dynamics of transportation policy occurred with Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) in 2005, which further strengthened the role of MPOs and RPCs in transportation planning and program implementation processes. The strengthening of RPCs through SAFETEA-LU changed the status quo in the intergovernmental system of transportation planning that had provided overwhelming power to the state governments vis-à-vis local and regional governments. Since SAFETEA-LU, two transportation bills have been authorized: Moving Ahead for Progress in the 21st Century Act, (MAP-21) in 2012 with 2-year funding authorization, and Fixing America's Surface Transportation Act (FAST) in 2015 with a 5-year funding authorization. Both MAP-21 and FAST continue to support the RPC funding mechanisms, while state and local governments continue to wield significant power over the allocation of surface transportation resources from the federal government through a complex process of prioritization of transportation projects in which regional governments were inserted as a mediating player (see Zia and Koliba 2015 for more details on intergovernmental project prioritization processes).

Fiscal relations can influence the power available to regional governments through legal regulation and financial autonomy (Greer 2006). Legal regulation refers to the procedures used by federal government to restrict decision-making powers of lower levels of governments, and financial autonomy is the extent to which a government controls its own revenue. Although U.S. states and local governments can collect some of their own revenues, they still rely on central spending power, so Greer cites the American system as an example of low fiscal autonomy (2006). The United States federal government, like many other countries, now provides more autonomy to its sub-national governments, but maintains its authority by imposing specific constraints along with the grants (Joumard and Kongsrud 2003). Gerber and Kollman (2004) outlined this kind of relationship in terms of "authority migration". Decisions made by the central government affected the structure of the financial flows in the system and the states and federal government continue to compete for their authority. The outcomes of the bargaining ultimately determine which actors have fiscal autonomy and decision-making power.

The U.S. Constitution leaves the majority of the tax-collecting powers to the federal government and only Congress and the President can determine how the federal government uses its spending power. This means the federal government has considerable power in raising revenue and defining how it is distributed. State and local government representatives can only influence this process by lobbying Congress (Watts 1999). With their fiscal power, the federal government employs state and local governments as fiscal administrators of federal programs. The sub-national governments have substantial authority, but the central government controls their power by offering mostly conditional grants. The federal government uses these attached constraints to accomplish three goals: incentivizing states to engage in national priorities, persuading states to modernize, and helping states take part in redistributive and welfare programs (Watts 1999).

The different federal transportation bills control the structure of the funding system. The Intermodal Surface Transportation Equity Act (ISTEA) of 1991 also introduced a fiscal constraint on the regional Transportation Improvement Program (TIP) and State Transportation Improvement Program (STIP). This requires MPOs to coordinate with local governments to generate an aggregate regional budget and identify specific federal funding sources for each project. Their budget must coincide with the STIP and the available federal funds (Goldman and Deakin 2000). Although most states favored this addition, local and regional governments were bound by the available federal programs (and thus federal priorities) and MPOs found this coordination to be a difficult task (Gage and McDowell, 1995). While some politicians have attempted to eliminate the federal program "silos" (Dilger 2010), the constraints of these programs can limit the availability of funds to certain geographic areas. The fiscal constraint gave MPOs more authority on the prioritization of projects, but only within the boundaries of federal priorities and budgets, so they also began to seek alternative funding sources (Bishop et al. 1997). Some regions are considering options for raising and allocating regional or local funds as a way to increase their financial autonomy (Sciara and Wachs 2007).

Some studies discuss capacity as an important measure of how capable local governments are of managing the responsibility as it relates to Federal-aid funds (Honadle 2001, Warner 1999). Honadle (2001) described local government capacity as something that is frequently changing and an important consideration in the context of increasing devolution. Warner (1999) noted that urban and rural areas have the highest costs and greatest needs in providing services, but they also have the most difficulty in raising local revenues. The ability to raise funds, according to Warner (1999), is bounded in part by local well-being and fundraising abilities are dispersed inequitably across the U.S. Honadle (2001) added that for local governments to manage greater responsibility after devolution of federal power, it was essential to have specialized expertise and professionalism in managing intergovernmental relationships. These notions are apparent in Deil Wright's concept of Intergovernmental Management (IGM) as government actors are all working together to achieve a specific goal (Wright 1990). The ability of a local government to cooperate or coordinate with other governments can determine their ability to participate in Federal-aid programs. Honadle (2001) highlighted approaches for effective IGM including focusing on the professionalism of public administrators and functional cooperation through intergovernmental agreements. If State governments do not factor in the disparities of local capacity, there will be a reinforcing cycle of an inequitable distribution of funds, particularly for rural areas (Warner 1999). So, in the face of broader federalist structure of intergovernmental relations, a compelling question arises from the perspective of local towns: Why some towns attract more federal and state funding than other towns? Are there some balancing and reinforcing feedback loops that influence some towns attracting more funds than others? We addressed these research questions through a participatory system dynamic model with an explicit focus on the intergovernmental influence (exogenous) and local town level technical and financial capacity (endogenous) dynamics. The system dynamic model is built in Stella Version 9.4, and calibrated to two local towns in Vermont.

Methods

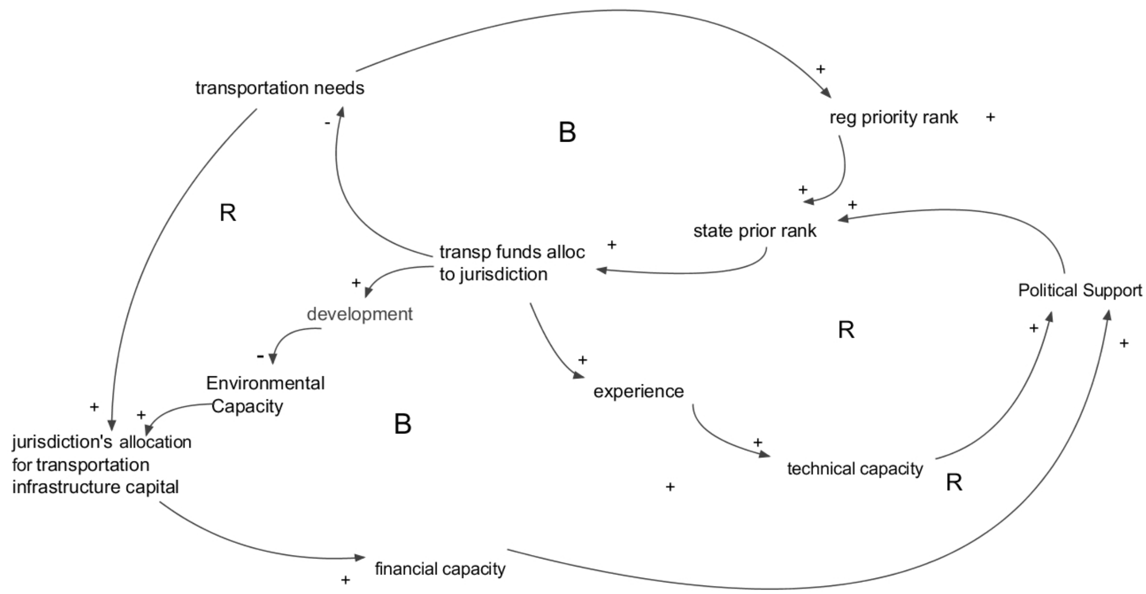
We formed the structure of the model according to responses from two focus groups with transportation professionals in the region and from the literature on the dynamics of federalist relationships. Using data between 1998 and 2010 from the Chittenden County Metropolitan Planning Organization's (CCMPO) Transportation Improvement Program (TIP), we were able to estimate the amounts requested from each jurisdiction, the amount obligated from the state to the region, and the amount obligated from the federal government to the region. We retrieved data on square miles of each town and population from the U.S. Census and collected gas price data from the Energy Information Administration. To estimate gas demand in Vermont, we used historical data from the Joint Fiscal Office on gas tax revenues. We also collected data on the number of technical reports and appearances at transportation advisory council (TAC) meetings from CCMPO's website.

We tested the model for two jurisdictions with data on transportation expenses from the towns' most recent budgets as an indicator for past expenses. We collected data on the number of professional planners from their website and assumed their interest in transportation planning and the cost-benefit to the state.

Causal Loop Diagram

The causal loop diagram (Figure 1) in the distribution system includes two balancing loops and three reinforcing loops. The first balancing feedback loop is with a jurisdiction's transportation needs. As a jurisdiction receives more transportation funds, they are able to meet more of their transportation needs and require fewer funds in the short term. The second balancing loop is with environmental capacity. With more development, there is less capacity to continue to build, so less money is allocated for new development. Three reinforcing loops include more money received leading towards more experience and thus greater technical capacity, more technical capacity directing a jurisdiction to more support from the MPO, and more transportation needs requires more transportation funds which ultimately gives a jurisdiction more financial capacity.

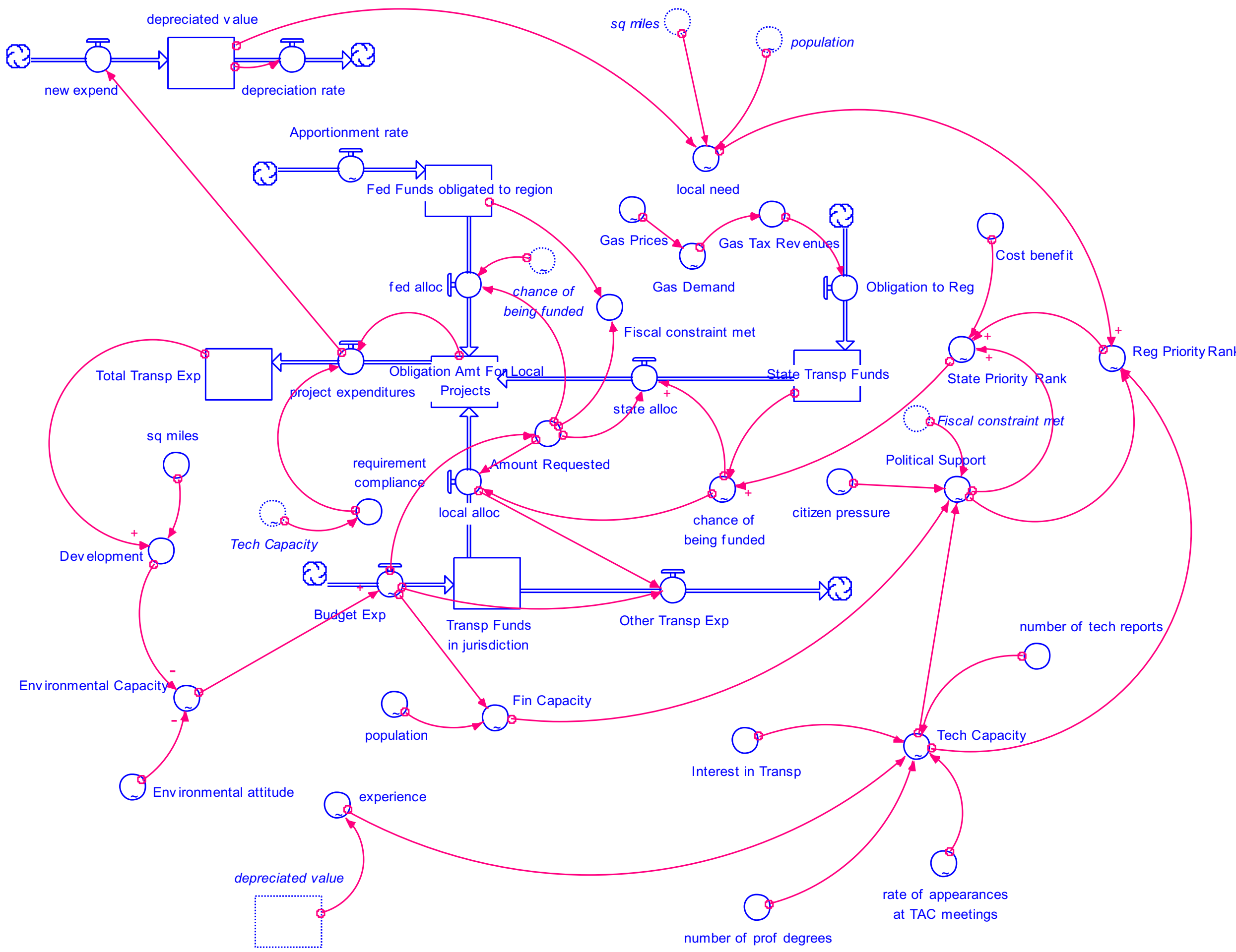
Figure 1. Causal Loop Diagram of the Distribution of Transportation Funds



The Model

The System Dynamics Model was built in Stella. Appendix I provides system of equations and parametric values and functions specified for the Jericho version of the model shown in Figure 2. The five main stocks of the model (Figure 2) include federal funds obligated to the region, obligation amount for local projects, state transportation funds, transportation funds in jurisdiction, and total transportation expenditures. We added a sixth stock called "depreciated value" as a way to represent the capital stock value of transportation infrastructure in the jurisdiction. This value affects the measure of local need in the jurisdiction. To reflect the restrictions of the federal government, the amounts requested must meet the fiscal restraint (meaning federal funds are available) for the jurisdiction to receive funds.

Figure 2. System Dynamics Model of the Distribution of Transportation Funds



As discussed in the focus group and in the literature, the local jurisdictions are more likely to attract transportation funds if they have more technical and financial capacity. Factors that affect technical capacity include the number of professional degrees on staff, rate of appearances at TAC meetings, number of technical reports published, and interest in transportation planning. Political support represents the ability of local jurisdictions to coordinate with multiple levels of government and any citizen pressure that may alter their plans. The state priority ranking is a function of cost benefit analysis, political support and regional priority ranking. This feeds into the variable "chance of being funded" which is a graphical function from 0 to 1 that determines the amount of funding that will be dispersed from the federal and state government and flows into the stock of local obligations.

Environmental capacity and local need are two variables that can balance the amount of funds received by a jurisdiction. Local governments that have significant developments will be limited by their environmental capacity of future development, hence this variable limits the potential of retrieving future funds. This can be in instances where additional growth becomes costlier or they are unable to meet the standards of the Environmental Impact Assessment. Local need is a function of population density and the depreciated value of transportation infrastructure. In the model, a jurisdiction with a greater depreciated value of capital stock has less transportation needs.

Limitations of the Model

Since the model assumes an initial depreciated value of zero in the first period (1998), the first three periods in the model do not accurately reflect the system. Not until period three (2001) does the system normalize after assuming that each jurisdiction has no preliminary transportation funds. To accommodate this, we analyze the results starting in 2001.

In order to test the model for specific jurisdictions, we assumed data for the cost-benefit value for the state, the environmental attitude and the jurisdiction's interest in transportation planning. An indicator of utility of added mobility or accessibility in each jurisdiction would be helpful in determining a true value for the cost-benefit analysis, but this data is unavailable. Analyzing each jurisdiction's interest in transportation planning could be best analyzed in future studies with in depth interviews. In order to test the model until 2025, we assumed future data beyond the twelfth period for gas prices, population, rate or appearances at TAC meetings, and local budget expenses.

The equation for amounts requested is estimated to be 1.5 times the amount budgeted by the local government, assuming that local governments ask for more money than was actually obligated on the TIP. By doing this, we assume that the amounts budgeted from the local government serve as an indicator of how much federal funds each jurisdiction needs or seeks. Citizen pressure was assumed for each year and in future iterations, these numbers could be empirically measured through interviews/surveys or focus groups.

Results

Testing the Model with Two Jurisdictions

By selecting Burlington VT, a city with over 3,500 people per square mile, and Jericho VT, rural town with a density of about 140 people per square, we compared model results for two jurisdictions with contrasting demographics. While the obligation amounts in the model for Burlington were not correct for each year, the total in the model of $37,000,000 is close to the actual amount of $39,000,000 between 2001 and 2010. The total obligation amounts to the jurisdiction varied each year, and over time Burlington builds up its technical capacity and political support (see Figure 3). The state and regional priority ranks cross around the third period as local need drops, but they follow the same course over time (see Figure 4). This is because the region ranks their projects according to local need, and the regional ranking accounts for 20% of the state ranking.

Figure 3. Output from Model for Burlington for Obligation Amounts, Technical Capacity, local need, and local allocation

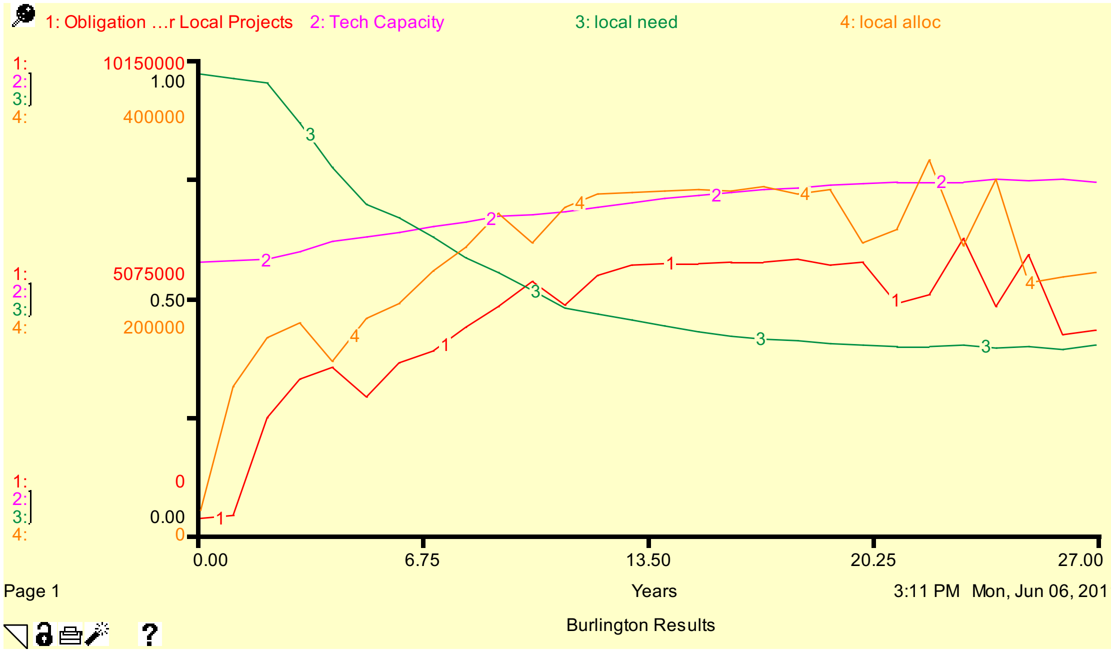
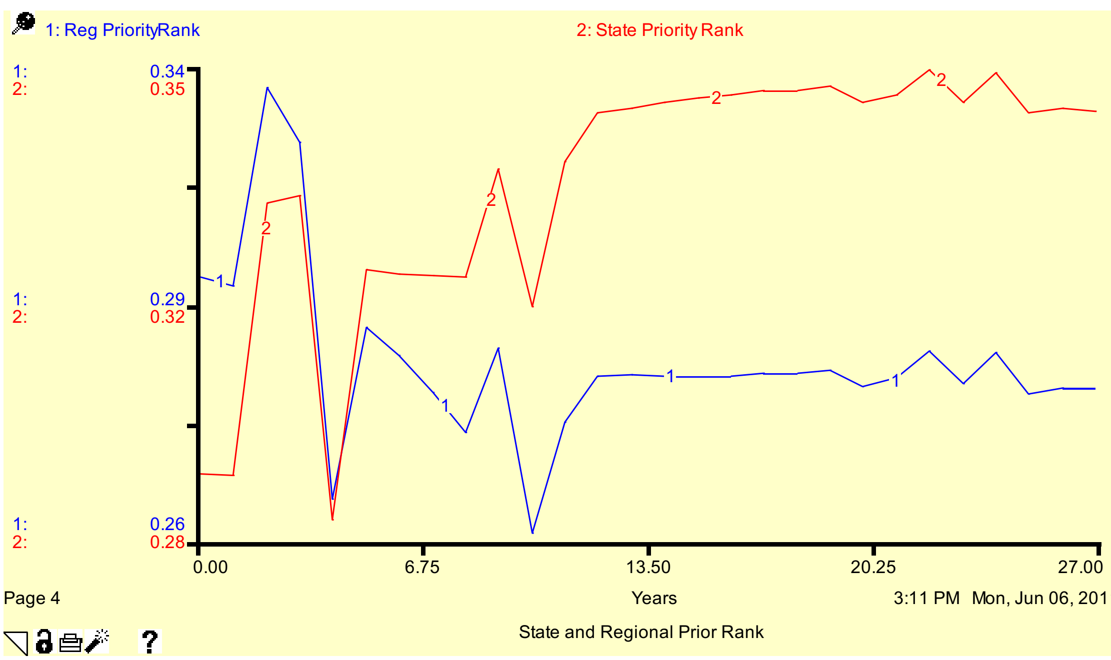
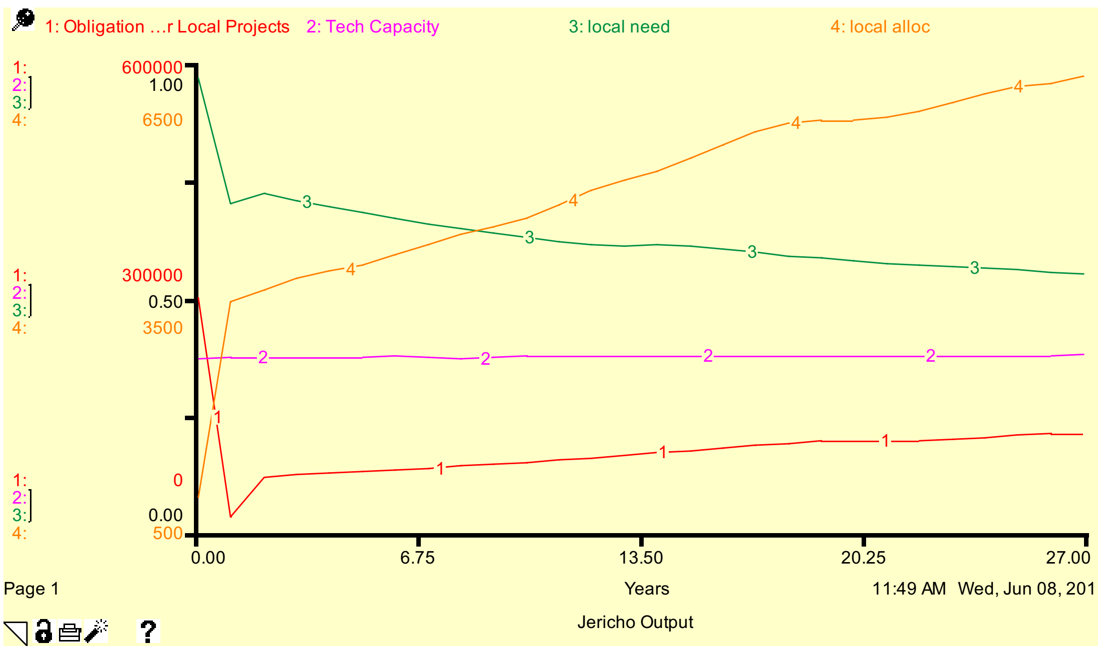


Figure 4. Output from Model for Burlington for State Priority Rank and Regional Priority Rank



Results from Jericho show much lower technical capacity and the obligation amounts in the model of $818,000 between 2001 and 2010 were a bit higher than the actual amount of $690,000. Since interest in transportation and cost-benefit analysis were assumed, a sensitivity analysis could produce results closer to the true values. Jericho's technical capacity remained relatively constant over the twenty-seven year period and their transportation needs slowly declined. This caused the obligation amounts to rise, but only slightly starting in the third period (see Figure 5).

Figure 5. Jericho Output for Obligation Amounts, Technical Capacity, Local Need, and Local Allocation



Sensitivity Analysis

To test the assumed variables, we ran a sensitivity analysis for interest in transportation and cost-benefit analysis. For interest in transportation, a value below 0.33 may cause the jurisdiction to have minimal technical capacity and be unable to spend any obligated funds. This is because their technical capacity is too low to meet the requirement compliance (see Figures 6 and 7). This could produce some unlikely results for this model, but it could be useful if incorporating annualized data on a local governments' interest in transportation planning. There may be certain years in which a jurisdiction did not attempt to receive transportation funds, and this variable would stop the jurisdiction from receiving funds in that year. As for the different outputs at each level of interest, there was about a 15% drop in funds received between a level of 1 and a level of .66 and about 15.5% drop between 0.66 and 0.33.

Figure 6. Graphical Output from Sensitivity Analysis of Interest in Transportation at 0, .33, .66, and 1 and Technical Capacity in Burlington

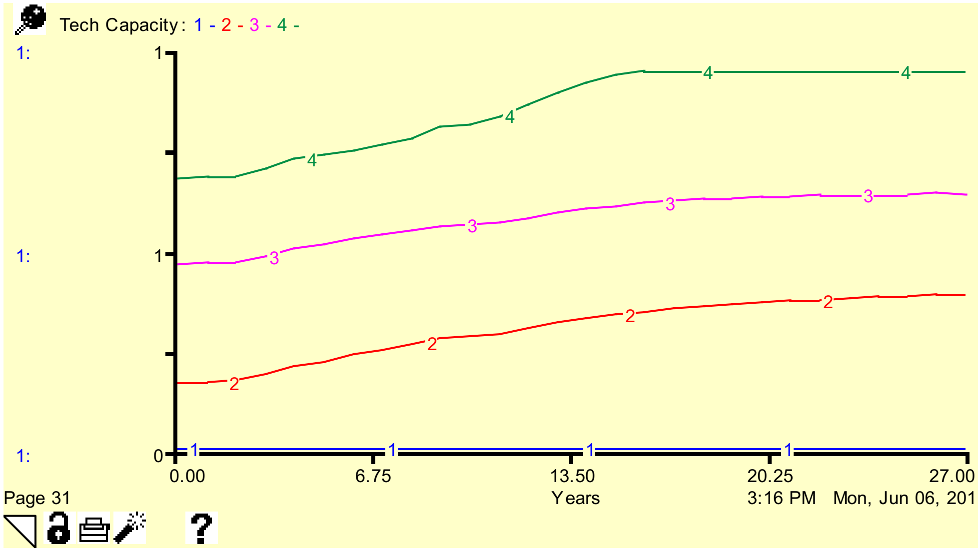


Figure 7. Graphical Output from Sensitivity Analysis of Interest in Transportation at 0, .33, .66, and 1 and Total Transportation Expenditures in Burlington

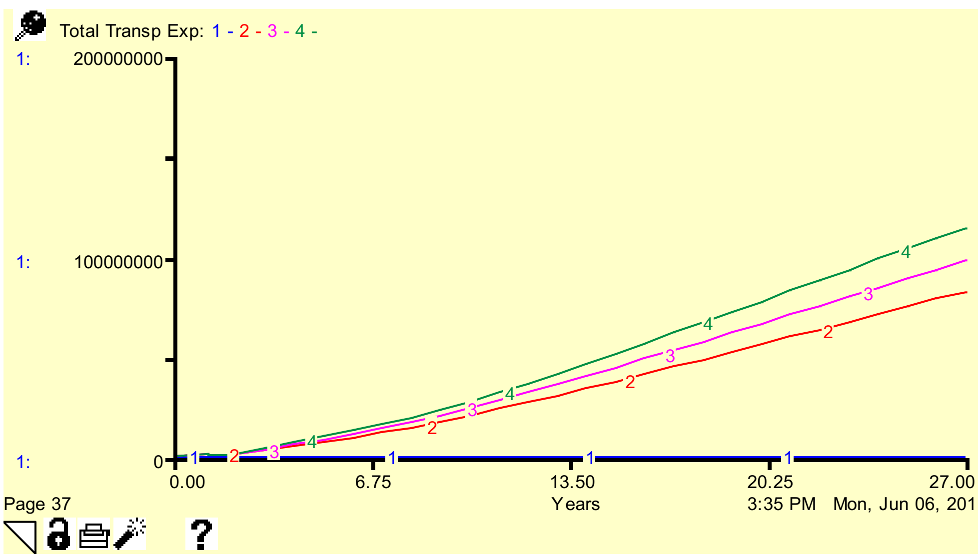
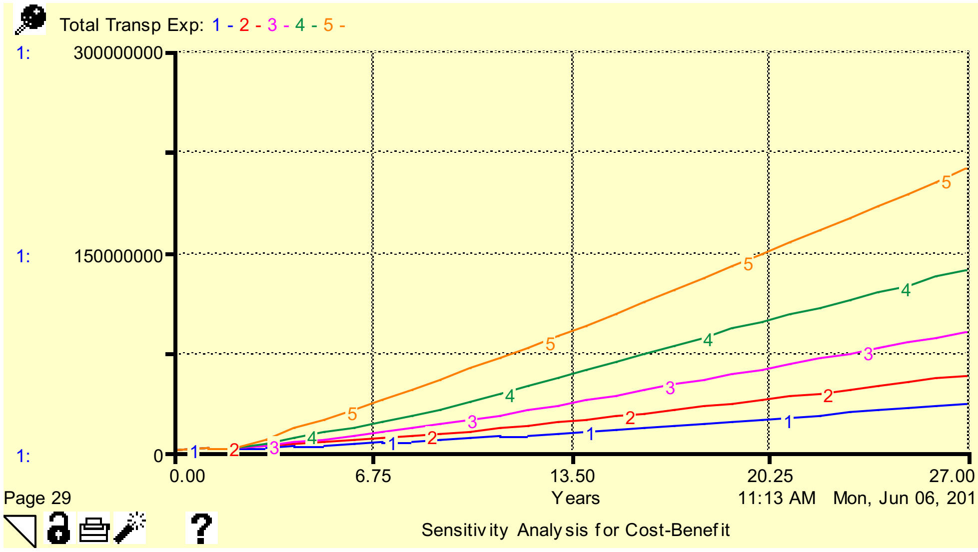
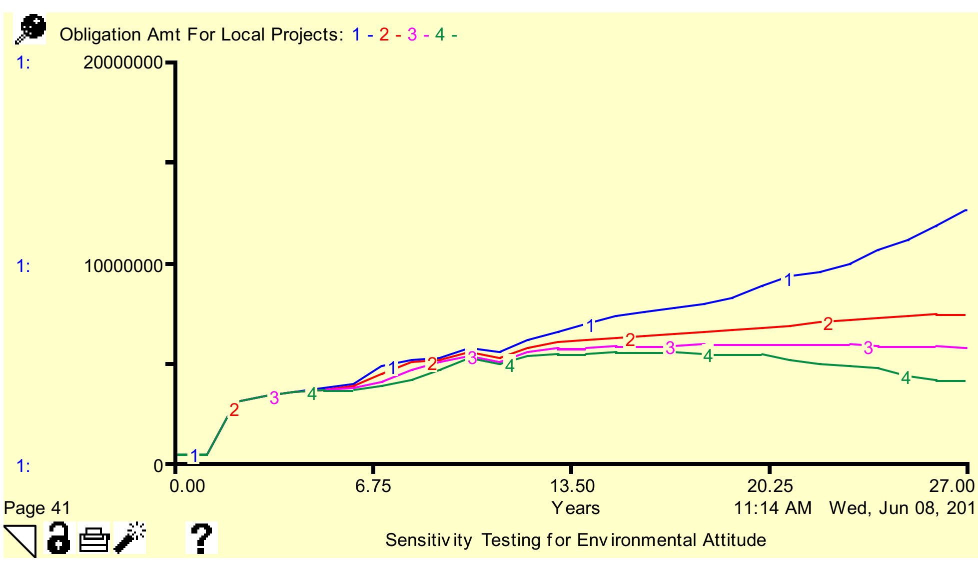


Figure 8. Graphical Output of Sensitivity Analysis for Cost-Benefit at 0, .25, .5, .75, 1 with Total Transportation Expenditures in Burlington



Environmental attitude, a measure of a jurisdiction's interest in limiting excessive development, was assumed as a graphical function over time in the model. In order to test the sensitivity of this value, we changed it to a constant value and tested it with the values 0, 0.33, 0.66, and 1. The differences are minor in the first thirteen years, but the variance is much greater after this time period (see Figure 7). With an attitude of 0, there was nearly twice as much development in period 27 than with an attitude of 0.33, suggesting the results from the model may be too extreme over time.

Figure 9. Sensitivity Analysis of Environmental Attitude at 0, 0.33, 0.66, and 1 in Relation to Obligation Amounts for Burlington



Citizen pressure, which we reflect as a graphical function over time, works as a check on a jurisdictions' political support. Without this variable in the model, jurisdictions receive a slightly higher amount of funds. Changing the amounts allocated from the local jurisdiction does have an impact on the amount of funds the local government receives.

Discussion

The model results rely on the balance between transportation need and jurisdictional capacity. An area with greater technical capacity and financial capacity may be able retrieve a higher level of funds regardless of their transportation needs. Likewise, jurisdictions without much capacity will receive funds because of their transportation needs. Another variable that plays a significant role is the amount budgeted which is reflected in the amounts requested. In this sense, it serves as another indicator of transportation needs and controls the potential obligation amounts.

This model sheds some light on the rural-urban divide, or lack thereof in transportation planning. While the Federal Programs attempt to rationalize the distribution of transportation funds, the state government actually holds significant power in this distribution process. The ability of jurisdictions with more interest, financial capacity, or technical capacity to retrieve more funds can explain why some areas receive more transportation funds even when accounting for population density and VMTs. This competition at the local level untangles the federal rules of distribution and allows for a process at the regional and state levels. While this does allow for more local input, it can also foster an attitude of "playing the system," or at least one that favors jurisdictions with the capacity to manage across levels of government. As Watts (1999) noted, the federal government employs the state government as fiscal administrators of transportation funds, and although there are Federal rules attached with this power, it also provides the state significant power in awarding funds.

As noted in Cresswell et al. (2002) and Luna-Reyes et al. (2007), simulation modeling can be useful in theory-building and for insights in intergovernmental relations. The structure of this model could be used by local towns and regions for insights into the dynamics of the planning process. Its validity would be strengthened with more complete data from in-depth interviews with town administrators. Future research could build on this model by adding in all jurisdictions to fully reflect the limited funds available to the region.

Conclusions

This paper develops a stakeholder driven system dynamics model to explore the dynamics of intergovernmental relations in the distribution of transportation funds from the viewpoint of local governments. The system dynamics model can shed light on issues such as why some towns attract more federal and state funding than other towns. The simulation model captures the structure of the system by positing five balancing and reinforcing feedback loops that influence some towns attracting more funds than others. The feedback loops in the stakeholder informed system dynamic model account for the intergovernmental influence (exogenous) and local town level technical and financial capacity (endogenous) dynamics. The model simulates two balancing loops (BL) and three reinforcing loops (RL). BL1: As a jurisdiction receives more transportation funds, they are able to meet more of their transportation needs and require fewer funds in the short term. BL2: With more development, there is less capacity to continue to build, so less money is allocated for new development. Three RLs include more money received leading towards more experience and thus greater technical capacity, more technical capacity directing a jurisdiction to more support from the MPO, and more transportation needs requires more transportation funds which ultimately gives a jurisdiction more financial capacity. The model was calibrated to two local towns in Vermont, one urban and the other being rural, and can be extended to other towns in future applications. The results explain the emergence of rural-urban divide, or lack thereof in transportation planning. Town governments can leverage financial and technical capacity to attract more transportation funds; however, changes in environmental attitude and land availability generate complex dynamics. Information and knowledge management approaches through assessing technical and financial capacities of town governments and their attitudes towards environment and development can explain the design and emergence of transportation infrastructure across urban to rural regions.

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References

Bishop ER, Wornum C, Weiss M. 1997. Experience of metropolitan planning organizations with intermodal surface transportation efficiency act financial planning requirements: Interviews and analysis. *Transportation Research Record*. **1606**: 1-8.

Cresswell AM, Black LJ, Luna LF. 2002. Modeling intergovernmental collaboration: A system dynamics approach. Presented at Hawaiian International Conference on System Sciences-35, Hawaii, 2002.

Dilger RJ. 2010. Federalism issues in surface transportation policy: Past and present. Congressional Research Service. Report 7-5700.

Gage RW, McDowell BD. 1995. ISTEA and the role of the MPOs in the new transportation environment: A midterm assessment. *Publius* **25**(3): 133-155.

Gerber ER, Gibson CC. 2009. Balancing regionalism and localism: How institutions and incentives shape American transportation policy. *American Journal of Political Sicence* **53**(3): 633-648.

Gerber ER, Kollman K. 2004. Introduction—authority migration: Defining an emerging research agenda. *PS: Political Science & Politics* **37**(3): 397-401.

Goldman T, Deakin E. 2000. Regionalism through partnerships? Metropolitan planning since ISTEA. *Berkeley Planning Journal* **14**: 46-75.

Greer SL 2006. The politics of divergent policy. In Greer S. (ed.) *Territory, Democracy and Justice*. Palgrave Macmillan, New York NY, 157-174.

Grizzle GA, Pettitjohn CD. 2002. Implementing performance-based program budgeting: A system-dynamics perspective. *Public Administration Review*, **62**(1): 52-62.

Honadle BW. 2001. Theoretical and practical issues of local government capacity in an era of devolution. *The Journal of Regional Analysis & Policy*, **31**(1): 77-90.

Joumard I, Kongsrud PM. 2003. Fiscal relations across government levels. *OECD Economic Studies*, **2003**(1): 155-229.

Koliba C, Meek JW, Zia A. 2010. *Governance Networks: Public Administration and Policy in the Midst of Complexity*. Taylor & Francis, New York.

Luna-Reyes LF, Andersen DF, Richardson GP, Pardo TA, Cresswell AM. 2007. Emergence of the Governance Structure for Information Integration Across Governmental Agencies: A System Dynamics Approach. Presented at the *International Digital Government Research Conference*, 2007.

Provan KG, Kenis P. 2008. Modes of network governance: Structure, management, and effectiveness. *Journal of Public Administration Research Theory*, **18**(2): 229-252.

Rich MJ. 1989. Distributive politics and the allocation of federal grants. *The American Political Science Review*, *83*(1): 193-213.

Sciara GC, Wachs M. 2007. Metropolitan transportation funding: Prospects, progress and practical considerations. *Public Works Management Policy*, **12**(1): 378-394.

Sterman, JD. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Irwin/McGraw-Hill, Boston.

Sorensen E, Torfing J. 2005. The democratic anchorage of governance networks. *Scandinavian Political Studies*, **28**(3): 195-218.

Warner ME. 1999. Local government financial capacity and the growing importance of state aid. *Rural Development Perspectives*, **13**(3): 27-36.

Waddell P. 2002. Modeling urban development for land use, transportation, and environmental planning. *Journal of the American Planning Association*, **68**(3): 297-314.

Watts RL. 1999. *The Spending Power in Federal Systems: A Comparative Study.* Institute of Intergovernmental Relations, Kingston, Ontario.

Wright, DS. 1990. Federalism, intergovernmental relations, and intergovernmental management: Historical reflection and conceptual comparisons. *Public Administration Review*, **50**(2): 168-178.

Zia A, Koliba C. 2015. The emergence of attractors under multi-level institutional designs: Agent-based modeling of intergovernmental decision making for funding transportation projects. *AI & society*, **30**(3): 315-331.

APPENDIX A

SYSTEM OF EQUATIONS AND PARAMETRIC VALUES USED FOR CALIBRATING THE SYSTEM DYNAMICS MODEL SHOWN IN FIGURE 2 TO JERICHO, VT

depreciated_value(t) = depreciated_value(t - dt) + (new_expend - depreciation_rate) * dt

INIT depreciated_value = 0

INFLOWS:

new_expend = project_expenditures

OUTFLOWS:

depreciation_rate = depreciated_value*.142

Fed_Funds_obligated_to_region(t) = Fed_Funds_obligated_to_region(t - dt) + (Apportionment_rate - fed_alloc) * dt

INIT Fed_Funds_obligated_to_region = 2.598e7

INFLOWS:

Apportionment_rate = GRAPH(TIME)

(0.00, 1e+007), (1.00, 1.2e+007), (2.00, 2.7e+006), (3.00, 2.5e+006), (4.00, 2.7e+007), (5.00, 2.9e+007), (6.00, 4.2e+007), (7.00, 4.2e+007), (8.00, 5.5e+007), (9.00, 4.7e+007), (10.0, 5e+007), (11.0, 6.3e+007), (12.0, 7.9e+007), (13.0, 8.2e+007), (14.0, 8.5e+007), (15.0, 8.8e+007), (16.0, 8.9e+007), (17.0, 9e+007), (18.0, 9.1e+007), (19.0, 9.2e+007), (20.0, 9.2e+007), (21.0, 9.2e+007), (22.0, 9.3e+007), (23.0, 9.3e+007), (24.0, 9.3e+007), (25.0, 9.3e+007), (26.0, 9.3e+007), (27.0, 9.6e+007)

OUTFLOWS:

fed_alloc = (Amount_Requested*.8)*chance_of__being_funded

Obligation_Amt_For_Local_Projects(t) = Obligation_Amt_For_Local_Projects(t - dt) + (state_alloc + fed_alloc + local_alloc - project_expenditures) * dt

INIT Obligation_Amt_For_Local_Projects = 300000

INFLOWS:

state_alloc = chance_of__being_funded*(Amount_Requested)*.15

fed_alloc = (Amount_Requested*.8)*chance_of__being_funded

local_alloc = Amount_Requested*chance_of__being_funded*.05

OUTFLOWS:

project_expenditures = if requirement__compliance <1 then 0 else Obligation_Amt_For_Local_Projects

State_Transp_Funds(t) = State_Transp_Funds(t - dt) + (Obligation_to_Reg - state_alloc) * dt

INIT State_Transp_Funds = 0

INFLOWS:

Obligation_to_Reg = Gas_Tax_Revenues/30

OUTFLOWS:

state_alloc = chance_of__being_funded*(Amount_Requested)*.15

Total_Transp_Exp(t) = Total_Transp_Exp(t - dt) + (project_expenditures) * dt

INIT Total_Transp_Exp = 0

INFLOWS:

project_expenditures = if requirement__compliance <1 then 0 else Obligation_Amt_For_Local_Projects

Transp_Funds_in_jurisdiction(t) = Transp_Funds_in_jurisdiction(t - dt) + (Budget_Exp - local_alloc - Other_Transp_Exp) * dt

INIT Transp_Funds_in_jurisdiction = 0

INFLOWS:

Budget_Exp = GRAPH(TIME*Environmental_Capacity)

(0.00, 940000), (1.00, 1e+006), (2.00, 1e+006), (3.00, 1.1e+006), (4.00, 1.1e+006), (5.00, 1.2e+006), (6.00, 1.2e+006), (7.00, 1.2e+006), (8.00, 1.3e+006), (9.00, 1.3e+006), (10.0, 1.3e+006), (11.0, 1.4e+006), (12.0, 1.4e+006), (13.0, 1.4e+006), (14.0, 1.4e+006), (15.0, 1.4e+006), (16.0, 1.5e+006), (17.0, 1.5e+006), (18.0, 1.6e+006), (19.0, 1.6e+006), (20.0, 1.6e+006), (21.0, 1.6e+006), (22.0, 1.6e+006), (23.0, 1.6e+006), (24.0, 1.6e+006), (25.0, 1.6e+006), (26.0, 1.6e+006), (27.0, 1.6e+006)

OUTFLOWS:

local_alloc = Amount_Requested*chance_of__being_funded*.05

Other_Transp_Exp = Budget_Exp-local_alloc

Amount_Requested = Budget_Exp*1.95

Cost_benefit = .3

Development = Total_Transp_Exp/sq_miles

Fiscal_constraint_met = if Amount_Requested> Fed_Funds_obligated_to_region then 0 else 1

Gas_Tax_Revenues = Gas_Demand*.2

Interest_in_Transp = .4

number_of_prof_degrees = 1

number_of_tech_reports = .92

requirement__compliance = if Tech_Capacity < .2 then 0 else 1

sq_miles = 35.39

chance_of__being_funded = GRAPH(if State_Transp_Funds >0 then State_Priority_Rank else 0)

(0.00, 0.01), (0.1, 0.03), (0.2, 0.045), (0.3, 0.065), (0.4, 0.105), (0.5, 0.175), (0.6, 0.355), (0.7, 0.505), (0.8, 0.63), (0.9, 0.805), (1, 1.00)

citizen_pressure = GRAPH(TIME)

(0.00, 0.485), (1.00, 0.485), (2.00, 0.49), (3.00, 0.515), (4.00, 0.555), (5.00, 0.56), (6.00, 0.525), (7.00, 0.495), (8.00, 0.44), (9.00, 0.43), (10.0, 0.45), (11.0, 0.48), (12.0, 0.475)

Environmental_attitude = GRAPH(TIME)

(0.00, 0.465), (1.00, 0.46), (2.00, 0.46), (3.00, 0.46), (4.00, 0.455), (5.00, 0.455), (6.00, 0.455), (7.00, 0.45), (8.00, 0.43), (9.00, 0.425), (10.0, 0.43), (11.0, 0.46), (12.0, 0.49), (13.0, 0.5), (14.0, 0.5), (15.0, 0.5), (16.0, 0.5), (17.0, 0.5), (18.0, 0.5), (19.0, 0.5), (20.0, 0.5), (21.0, 0.5), (22.0, 0.5), (23.0, 0.5), (24.0, 0.5), (25.0, 0.5), (26.0, 0.5), (27.0, 0.5)

Environmental_Capacity = GRAPH(Development*Environmental_attitude)

(0.00, 0.97), (1e+006, 0.825), (2e+006, 0.7), (3e+006, 0.6), (4e+006, 0.52), (5e+006, 0.45), (6e+006, 0.385), (7e+006, 0.325), (8e+006, 0.27), (9e+006, 0.24), (1e+007, 0.185)

experience = GRAPH(depreciated_value)

(0.00, 0.005), (1e+007, 0.065), (2e+007, 0.12), (3e+007, 0.18), (4e+007, 0.235), (5e+007, 0.28), (6e+007, 0.395), (7e+007, 0.505), (8e+007, 0.62), (9e+007, 0.81), (1e+008, 1.00)

Fin_Capacity = GRAPH(Budget_Exp/population)

(0.00, 0.03), (500, 0.1), (1000, 0.19), (1500, 0.28), (2000, 0.375), (2500, 0.495), (3000, 0.63), (3500, 0.685), (4000, 0.74), (4500, 0.805), (5000, 0.97)

Gas_Demand = GRAPH(Gas_Prices)

(0.00, 4e+008), (1.00, 3.3e+008), (2.00, 3e+008), (3.00, 3e+008), (4.00, 3.3e+008), (5.00, 3.1e+008), (6.00, 2.9e+008), (7.00, 2e+008)

Gas_Prices = GRAPH(TIME)

(0.00, 1.05), (1.00, 1.16), (2.00, 1.52), (3.00, 1.43), (4.00, 1.36), (5.00, 1.57), (6.00, 1.88), (7.00, 2.29), (8.00, 2.59), (9.00, 2.81), (10.0, 3.29), (11.0, 2.38), (12.0, 2.84), (13.0, 3.33), (14.0, 3.85), (15.0, 4.13), (16.0, 4.31), (17.0, 4.62), (18.0, 4.90), (19.0, 5.46), (20.0, 5.99), (21.0, 6.51), (22.0, 6.65), (23.0, 6.69), (24.0, 6.69), (25.0, 6.69), (26.0, 6.69), (27.0, 7.00)

local_need = GRAPH(depreciated_value/(population/sq_miles))

(0.00, 0.97), (2000, 0.715), (4000, 0.58), (6000, 0.475), (8000, 0.42), (10000, 0.375), (12000, 0.33), (14000, 0.3), (16000, 0.27), (18000, 0.255), (20000, 0.21)

Political_Support = GRAPH(if Fiscal_constraint_met <1 then 0 else (Tech_Capacity+Fin_Capacity-(citizen_pressure*.50)))

(0.00, 0.01), (0.2, 0.115), (0.4, 0.185), (0.6, 0.275), (0.8, 0.395), (1.00, 0.5), (1.20, 0.58), (1.40, 0.655), (1.60, 0.745), (1.80, 0.89), (2.00, 1.00)

population = GRAPH(TIME)

(0.00, 4730), (1.00, 4785), (2.00, 5032), (3.00, 5058), (4.00, 5059), (5.00, 5066), (6.00, 5075), (7.00, 5073), (8.00, 5082), (9.00, 5113), (10.0, 5135), (11.0, 5135), (12.0, 5200), (13.0, 5320), (14.0, 5600), (15.0, 5760), (16.0, 5800), (17.0, 5800), (18.0, 5800), (19.0, 5960), (20.0, 5960), (21.0, 5960), (22.0, 6040), (23.0, 6040), (24.0, 6040), (25.0, 6080), (26.0, 6080), (27.0, 6120)

rate_of_appearances_at_TAC_meetings = GRAPH(TIME)

(0.00, 0.18), (1.00, 0.18), (2.00, 0.18), (3.00, 0.18), (4.00, 0.25), (5.00, 0.5), (6.00, 0.855), (7.00, 0.3), (8.00, 0.00), (9.00, 0.55), (10.0, 0.77), (11.0, 0.77), (12.0, 0.55), (13.0, 0.755), (14.0, 0.755), (15.0, 0.755), (16.0, 0.755), (17.0, 0.755), (18.0, 0.755), (19.0, 0.755), (20.0, 0.755), (21.0, 0.755), (22.0, 0.755), (23.0, 0.755), (24.0, 0.755), (25.0, 0.755), (26.0, 0.755), (27.0, 0.755)

Reg_PriorityRank = GRAPH(local_need+Tech_Capacity+Political_Support)

(0.00, 0.01), (0.3, 0.06), (0.6, 0.105), (0.9, 0.15), (1.20, 0.21), (1.50, 0.29), (1.80, 0.345), (2.10, 0.47), (2.40, 0.605), (2.70, 0.725), (3.00, 1.00)

State_Priority_Rank = GRAPH((Political_Support*.2) +(Reg_PriorityRank*.2)+(Cost_benefit*.6))

(0.00, 0.005), (0.1, 0.055), (0.2, 0.095), (0.3, 0.19), (0.4, 0.275), (0.5, 0.365), (0.6, 0.44), (0.7, 0.545), (0.8, 0.645), (0.9, 0.755), (1, 1.00)

Tech_Capacity =
GRAPH((experience*rate_of_appearances_at_TAC_meetings)+((number_of_tech_reports/number_of_prof_degrees)*(Interest_in_Transp)))

(0.00, 0.015), (0.075, 0.09), (0.15, 0.165), (0.225, 0.245), (0.3, 0.305), (0.375, 0.375), (0.45, 0.53), (0.525, 0.655), (0.6, 0.775), (0.675, 0.86), (0.75, 1.00)