Exploring Integration in Public Choice Economic Theory: A System Dynamics Approach

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Abstract: Using a system dynamics perspective, this paper explores the links between two models in mainstream Public Choice Theory, the Median Voter Model and the Tiebout Hypothesis. By grounding this model of public choice dynamics in economic theory, we present the dynamic implications of both models as they interact and form one integrated model. Additionally, by relaxing the assumptions of the integrated model, we explore the effects these relaxations have on public choice behavior and the configuration of society over time. Finally, we present a set of conclusions and directions for future research.

Keywords: Voting Behavior, Public Choice Dynamics, Median Voter Model, Tiebout Hypothesis, Voting with your Feet, System Dynamics

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"The function of a unified theory is to integrate and synthesize existing knowledge within the existing paradigm, not to propose new questions and radically different answers."

Allen Newel, (page 395) Unified Theories of Cognition (1990)

This research intends to propose 'dynamic' considerations in the voting process that would add to the 'static' understanding of the median voter model and the Tiebout hypothesis. It is suggested that changes in the composition of voters will influence the median-voter profile that, in turn, will have an effect on the 'demand' for public goods that emerges from the composition of the 'new' median voter. This suggests that (1) individuals trying to maximize their preferences will 'act' as a consequence of government policies, and (2) legislators and public officials trying to maximize their 'political' profits will satisfy the demand generated by the 'dynamic' median voter. A key element of this Public Choice Model is the recognition of the circular causality generated by the decisions of the median voter with the government policies over time. Thus, suggesting that changes in government policy are endogenous to the system and created by the implementation of the policies themselves.

Introduction

Public Choice Theory deals with the economic study of nonmarket decision making, or put differently is the application of economics to political-science type of questions (Mueller, 1989, p. 1). In public choice theory a number of economic models exist that try to address the public-choice view of the world (Mueller, 1989, p. 3); the median voter model and the Tiebout hypothesis are prominent in their attempt to explain certain types of observed behavior in society. The median voter model has been identified as a model of public demand aggregation (Holcombe, 1989, p. 119) and the Tiebout Hypothesis as a model of demand reconfiguration that influences public sector production output decisions (Tiebout, 1956, p. 420).As with many other economic models, critics argue that these two models are inadequate because of the unrealistic sets of assumptions inherent in the models.

This research attempts to articulate a 'dynamic' and 'integrated' view of the voting process that will synthesize the elements of the median voter model and the Tiebout hypothesis into what we perceive as a model of public choice dynamics. We are building on existing related research that combines the Tiebout hypothesis and the median voter model (see Pogodzinski and Sjoquist, 1991) and expanding the scope by using a formal dynamic modeling technique to address this integration. We argue in this paper that the

median voter model and the Tiebout hypothesis create a good static explanation of political outcomes but lack a dynamic component that prevents them from explaining long-term behavior. We present an integrated model of the two theories that, by recognizing the feedback mechanisms that change the structure of society's profile at any given point in time, helps explain the oscillatory character of society's composition that influences public sector production output decisions and public sector demand configuration.

The paper is structured as follows. In section I we present the theoretical base for the model explaining what public choice theory is, what the median voter model implies, what the Tiebout hypothesis depicts, and some links between the models. Section II presents the integrated theory in the form of a system dynamics model. We explain the structure of the model, its assumptions, the behavior that it generates and what happens when we relax the assumptions of the integrated model. Finally, in Section III, we present conclusions and directions for future research opportunities. Appendices one and two present the full sets of equations for the models built using Vensim©.

I. Public Choice Economics and its Theories

A. Public Choice Economics

Public choice economics can be defined as "the economic study of nonmarket decision making, or simply the application of economics to political science." (Mueller, 1989, p. 1) Political science often assumes that it is human nature to be political and therefore, individuals will pursue activities in the public interest. Economics has often assumed that it is human nature to be economic and therefore, individuals will pursue activities in their own self-interest. The field of public choice economics attempts to join the political and economic perspectives on the nature of man. However, while public choice economics assumes that man can be both economic and political at the same time, it still assumes that human behavior is egoistic, rational and utility maximizing.

The subject matter of public choice often involves areas similar to those studied in political science. The theory of the state, voting rules, voter behavior, party politics, and bureaucracy are just some of the

subjects of interest in public choice economics. Public choice literature is concerned with decisions made in direct democracies and representative democracies alike. In representative democracies, public choice literature has mainly focused on three areas, the behavior of representatives both during the campaign to be elected and while in office, the behavior of voters in choosing representatives, and the characteristics of the outcomes under representative democracy. The public choice approach assumes that representatives, like voters, are rational, economic individuals bent on maximizing their utilities (Mueller, 1989, p. 179)

In public choice economics, the median voter model and the Tiebout hypothesis are among the models attempting to explain the behavior of voters and legislatures. By understanding the basic assumptions and functions of the median voter and Tiebout models we can begin to conceptualize links between the two models that will lead to a better understanding of the potential dynamic considerations involved in the voting process.

B. The Median Voter Model

The median voter can be thought of as the person who's bliss point or ideal level of a public good is the median level of that public good. The median voter theorem suggests that under majority rule, the median voter's preferences will be expressed if two specific assumptions are met. First, the issue under consideration must be unidimensional. It is often suggested that most issues can be viewed as multidimensional, rather than unidimensional. For example, the Vietnam war raised issues regarding U.S. military presence overseas as well as humanitarian concerns for the human destruction it brought. A voter may favor high levels of defense spending to achieve U.S. presence abroad in one dimension, but also a complete military pull out to stop human destruction in another dimension (Mueller, 1989, p. 67). Second, the voter's preferences must be single peaked (Mueller, 1989, pp. 65-66). When voting on a public good supply issue, voters who have single-peaked preferences agree that there is an optimum amount of the public good that should be supplied (Mueller, 1989, p. 67). If these two assumptions are

not met, the possibility of cycling exists. Cycling occurs when we let voters continue to vote, but we never reach equilibrium or a superior outcome.

Using an example, the median voter theorem is illustrated in Figure 1. In this example there are three voters voting on how large the local school budget should be. Voter 1 prefers a small budget. Voter 2 prefers a medium-sized budget. Voter 3 prefers a large budget. Points 1, 2, and 3 represent each voter's bliss point or ideal school budget level. Moving along the voter's utility curve, the farther away from the voter's bliss point, the worse off that voter is. The area between points A, B, and C is the only area where all three voters have some common level of utility. If we put a small budget up for a vote against a large budget, and we allow enough voting, eventually we would end up with a medium sized budget, because this is the only area where all three types of voters have a common level of utility. This is also the optimum level for the median voter, thus the median voter's preferences are expressed.

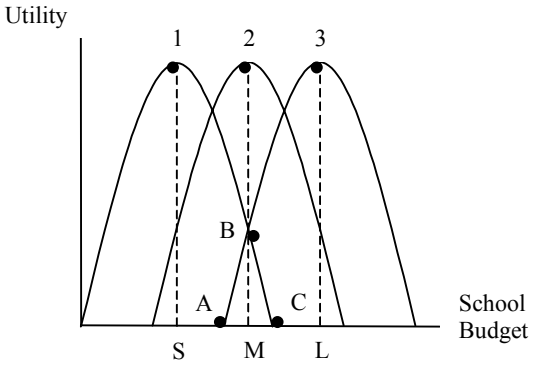


Figure 1—Example of The Median Voter Model

Several weaknesses inherent in the median voter model are evident in the literature. First, the model is often criticized for lacking a supply side component. Niskanen (1971) built a model of a budget maximizing bureaucracy. While the median voter model was used as the basis for the demand side if this model, Niskanen employed a new supply side of the market component as well. With the addition of the supply side component, Niskanen's new model had conclusions that were at odds with the generally accepted conclusions of the median voter model.

Second, some suggest that the two key assumptions of the median voter model, unidimensionality and single peakedness, are unrealistic and therefore the median voter model is not useful. In the real world even if voter preferences are single peaked, it is difficult to view many issues as unidimensional. McKelvey (1976) used a model similar to the median voter model. However, in this model, political issues were multidimensional rather than unidimensional.

Despite the theory's limitations, Holcombe (1989) argues in favor of the utility of the median voter hypothesis in public choice theory. He recognizes that this model is only a model of demand aggregation under majority rule and it omits the supply side of the public sector. While the assumptions of the median voter theory may have very limited applicability in the real world, Holcombe (1989) cites specific empirical and theoretical evidence supporting the median voter model. Just because the median voter theory is not directly applicable to every political market, does not mean that it cannot provide a base upon which a more complete analysis of public sector demand can be built. Holcombe (1989) suggests that if we set aside the overly aggressive assumptions that this model makes, the median voter model provides a good foundation upon which to develop a theory of political structure that is comparable to the theory of market structure in economics.

C. The Tiebout Hypothesis

The phrase "voting with one's feet" suggests that individuals communicate their preferences for public goods by the communities in which they choose to live. So, if individuals are dissatisfied with the community they live in, they will express this by choosing to move to a different community that better represents their preferences. The idea of "voting with one's feet" was introduced by Charles Tiebout (1956) in his article, "*A Pure Theory of Local Expenditures*." In this article, he argues that:

> "The consumer-voter may be viewed as picking that community which best satisfies his preference pattern for public goods….at the local level various governments have their revenue and expenditure patterns more or less set. Given these revenue and expenditure patterns, the consumer-voter moves to that community whose local government best satisfies his set of preferences." (p. 418)

Tiebout is asserting that individuals will choose to live in the community that most highly satisfies their preferences for local expenditures. Tiebout raises this argument in response to findings by Musgrave (1939) and Samuelson (1954) suggesting that there is no "market-type" solution to determine the level of expenditures on public goods. Tiebout (1956, p. 416) agrees that this is true for federal expenditures, but contends that this is not necessarily true for local expenditures. According to Tiebout's (1956, p. 424) analysis, there is a conceptual solution for the determination of the local level of expenditures on public goods. The hypothesis states that if consumer-voters are completely mobile, consumer-voters will choose to adopt the local government whose revenue-expenditure patterns are set and meets their preferences most (Tiebout, 1956, p. 424).

To illustrate this hypothesis, Tiebout (1956, p. 419) presents a local government model based on seven assumptions. The assumptions are:

1. Consumer-voters are fully mobile and will move to that community where their preference patterns, which are set, are best satisfied.

2. Consumer-voters are assumed to have full knowledge of differences among revenue and expenditure patterns and can react to these differences.

3. There are a large number of communities in which the consumer-voters may choose to live.

4. Restrictions due to employment opportunities are not considered. It may be assumed that all persons are living on dividend income.

5. The public services supplied exhibit no external economies or diseconomies between communities.

6. For every pattern of community services set by, say, a city manager who follows the preferences of the older residents of the community, there is an optimal community size. This optimum is defined in terms of the number of residents for which this bundle of services can be produced at the lowest average cost…Such a cost function implies that some factor or resource is fixed.

7. Communities below the optimum seek to attract new residents to lower average costs. Those above optimum size do just the opposite. Those at an optimum try to keep their populations constant.

Based on these assumptions, Tiebout (1956) constructs a model depicting the movement decisions of voters. The model asserts that except when the system is in equilibrium, there will be a set of consumer-voters who are not satisfied with the revenue-expenditure patterns of their current locality and a set of consumers who are satisfied with the revenue-expenditure patterns of their current locality. As a result, consumer-voters will move into and out of communities based on their revenue-expenditure preferences. Movement will take place out of the communities that are larger than optimal size and into the communities that are smaller than optimal size. The decisions that consumer-voters make to move or not to move reveals the consumer-voter's demand for public goods and acts as the market test of willingness to purchase a good. Given these conclusions and the assumptions the model is based on, each locality has a revenue and expenditure pattern that reflects the desires of its residents (Tiebout, 1956, p. 420).

Several criticisms of the utility of the Tiebout hypothesis are evident in the literature. First, the applicability of the Tiebout hypothesis depends on the particular public expenditure. Edel and Sclar (1974) suggest that even if the Tiebout model holds for public expenditures on things such as schools, it does not hold for public expenditures on things such as road maintenance. The accuracy of the Tiebout model for public expenditures depends on whether or not supply conditions are in long run equilibrium (Edel and Sclar, 1974, p. 942). In light of their findings, the authors caution the acceptance of the Tiebout hypothesis as a "market-type" solution to determining the efficient public expenditure levels.

Second, the Tiebout hypothesis does not consider the voting activities of individuals once they select the community that most closely represents their preferences. Tullock (1971, p. 913) suggests that democratic governments exist to deal with public goods. The process used to make decisions regarding public goods, can generate additional issues. Tullock argues that in choosing a community in which to reside, individuals will consider the private effects of the bundle of government services and taxes offered by a community. The majority of the cost of this decision falls on the individual. Once the individual

selects a community and moves there, that individual has very little motive to vote intelligently because they do not internalize the full benefit of their decision. Therefore, the tendency for communities to adjust to the true demand of residents is weaker than if these communities were profit-making firms (Tullock, 1971, p. 917). Tullock suggests that decision making in democratic communities leads to ill-considered decisions that result in less than optimal production of public goods (Tullock, 1971, p. 918).

Third, the Tiebout hypothesis only holds under very restrictive assumptions. Among the circumstances when the Tiebout hypothesis will not hold are when local governments are democratic in nature in that they try to promote the welfare of their own citizens and when local communities are governed by majority rule (Bewley, 1981, p. 713). Due to the effects of migration, if the per capita cost of public goods is not proportional to the regional population, the Tiebout hypothesis will not hold (Bewley, 1981, pp. 717-719). Bewley uses the example of a locality where land is a factor in production (i.e. farming). He asserts that when consumers make decisions to move into a locality, they do not consider economies of scale that result when they relocate. Immigration reduces the per capita cost of the public good (land), but also reduces the per capita return from working the land. Thus, this situation would not be Pareto optimal. Some farmers may be left worse off because the returns from working the land will decrease.

Donahue (1997) argues that not all citizen preferences for public expenditures will be recognized appropriately. He cites the example of gambling regulation. If a state does not allow gambling, they risk losing citizen dollars to other states that do allow gambling and losing the potential monies that gamblers from other states will bring with them. When states try to avoid such risks, we end up with fewer restrictions on gambling than the citizenry may prefer (Donahue, 1997, p. 77). In addition Donahue suggests not all citizens have homogenous mobility. As interstate competition grows, policies can be expected to favor those citizens who are most mobile at the expense of those citizens who are less mobile. Donahue cites the example of a retiree who's after tax pension is substantially affected by state policies. This individual may be more likely to incorporate state policies into locational decisions. This individual

may not represent the median individual, but may have more impact on state policies (Donahue, 1997, p.78).

Fourth, some question whether or not the competition between local jurisdictions inherent in the Tiebout hypothesis is alone sufficient to provide efficient provision of public goods (Epple and Zelenitz, 1981, p. 1198). They find that the mobility of individuals across a large number of jurisdictions can prevent individual governments from exercising monopoly power, but this alone is not enough (Epple and Zelenitz, 1981, p. 1216). Their model suggests that the assumption that jurisdictions have fixed boundaries means that governments can exploit the immobility of land and the housing supply in their jurisdiction with their taxing powers. Their final conclusion is that the Tiebout model must include politics to be applicable.

Fifth, in attempting to empirically determine the demand for public goods in a locality it would be more appropriate to use individual observations in situations where the Tiebout hypothesis holds and to use the median voter model for observations taken from geographically isolated areas. Goldstein and Pauly (1981) suggest several things. First, when using the median voter model to empirically determine the demand for public goods in a locality does not take into account the possibility of bias (Goldstein and Pauly, 1981, p. 132). If the Tiebout hypothesis holds and the households in a community have similar preferences this could result in bias if these households are used to estimate demand for public goods. Second, they assert that if a Tiebout-type equilibrium exists, one can determine the demand for public goods by selecting a random sample of households across all communities and the quantity of public goods demanded can be estimated based on family budget data, family taxes, and the family's utility maximizing expenditure on the particular public good in question (Goldstein and Pauly, 1981, p. 133).

D. A Blueprint of the Links Between the Median Voter Model and the Tiebout Hypothesis

As discussed above there are criticisms of both the median voter model and the Tiebout hypothesis evident in the literature. By integrating the median voter model and the Tiebout hypothesis into one

dynamic model, we can combine the strengths of each individual model to create an integrated model with a higher level of utility.

There are seven conceptual links between the median voter model and the Tiebout hypothesis. First, in joining the median voter model and the Tiebout hypothesis, we can view a "bundle" of public goods as unidimensional. The median voter model is often criticized as being unrealistic because for the model to work, the issue under consideration must be unidimensional. In reality, very few issues are truly unidimensional. By combining the unidimensional assumption of the median voter model with the assumption that consumer-voters sort themselves into relatively homogenous communities by choosing to live in the community that best meets their preference pattern for public goods of the Tiebout hypothesis, we can assert that consumer-voters view the "bundle" of public goods as unidimensional. While the provision of each individual public good in the bundle may not exactly meet the voter's preferences, the voter will evaluate the bundles of various communities as a whole and move to the community with the bundle that *best* meets their preference pattern. Thus, the voter recognizes that the bundle of public goods is made up of many parts, but is voting on the bundle itself, by choosing to live in the community where the bundle of public goods best meets their preference pattern.

Second, combining the median voter model and the Tiebout hypothesis might provide a more comprehensive mechanism to determine the demand functions of individuals for public expenditures. Goldstein and Pauly (1981) suggest that, when attempting to estimate the demand functions of individuals for public expenditures, it is appropriate to use individual observations in situations where a Tiebout-type equilibrium exists, and the median-voter model when geographically isolated areas exist. By combining the Tiebout hypothesis and the median-voter model, we may be able to provide a more widely applicable method of capturing the demand functions of individuals as well as aggregates for public expenditures.

Third, to adequately link the median voter model and the Tiebout hypothesis, we must extend the assumption of the Tiebout hypothesis that the model applies only to local voting behavior to the median voter model as well. In the abstract, the Tiebout hypothesis appears to be applicable to federal cases as well. Migration between different countries could be explained as people 'voting with their feet' by

moving from one federation to another—from one country to another. This migratory phenomenon can be linked to the 'bundle' of goods and services provided by the different countries—including job opportunities, economic prosperity, etc. However, for the Tiebout hypothesis to hold in a federal situation, we would need a more complicated model with deeper assumptions about barriers to entry and exit, citizen mobility, available employment opportunities, etc. Thus, the joining of the median voter model and the Tiebout hypothesis into one dynamic model is an attempt to provide an explanation of public choice behavior and public goods provision at a 'local' level.

Fourth, while the Tiebout hypothesis alone only addresses public sector demand, the integrated model will provide explanations for voting patterns, migration choices, as well as public goods supply and demand included in one model.

Fifth, one of the implications of the Tiebout hypothesis is that the chances for wealth redistribution are reduced. However, our integrated model suggests that the homogenous communities and equilibrium posited in the Tiebout hypothesis are never completely reached. Communities will not be totally homogenous as long as individuals are continuously moving in and out of them. We propose that there is a time delay element in voter decision processes and government response to these processes. Thus, there is some level of continuous wealth redistribution as citizens move in and out of communities.

Sixth, our integrated model incorporates the realistic assumption that cycling will occur in society. The median voter theory implies that never reaching an equilibrium or a superior outcome (cycling) is undesirable. However, the median voter model will only be applicable when cycling does not occur. By including cycling in our model we have expanded the utility of the median voter model.

Seven, one of the major contentions in this paper is that we can join the median voter model and the Tiebout model by suggesting that that the voting process involved in both models has a dynamic element. As consumer-voters move from community to community seeking the community that best meets their preference pattern for public goods, the composition of the median voter population within each community will change. Thus, as the government initiates production of public sector output and public policy actions, consumer-voters can respond by voting with their feet and moving to a different

community. As voters move to different communities, the attributes of the median voter within each community may change.

II. A Dynamic Theory of Public Choice Behavior

The dynamic analysis of behavior makes sense when you encounter important, hard to understand, and recurrent phenomenon that you are interested in exploring. '*Important'* refers to the idea that there is a constituency that cares about that phenomenon and that is willing and able to try to do something about the state of the world (Richardson and Pugh, 1981). *'Hard to understand'* refers to the sense that other ways of looking at the phenomenon generate inconclusive outcomes or contradicting theories that do not help to clarify the phenomenon. In addition, *'recurrent'* refers to the notion that the phenomenon appears and reappears through time creating the opportunity to understand it as a series of events not just one isolated event. To understand the dynamics of a system there are several theoretical lenses available. System dynamics, because of its feedback approach (Richardson, 1991), is ideal for this analysis. System dynamics modeling has proven valuable for modeling cycling behavior in a number of settings (Sterman, 2000, pp. 792-800) especially commodity cycles. Voting patterns and political processes can be understood as commodities in the sense that they are undifferentiated products, supplied by small independent producers (voters) so that the market is approximately competitive (majority rule). A conceptual system dynamics model is used to describe how a dynamic and integrated view of the median-voter model and the Tiebout hypothesis can help explain patterns in voting, public goods supply and demand, and the migration decisions of voters.

A. Why use system dynamics?

System dynamics has been used for the development of dynamic theories of behavior (see Creswell et al., 2001). System dynamics seeks to understand the behavior of a system by discovering the structure that conditions that behavior and by focusing on creating an endogenous explanation of the phenomenon of interest. In order to create a dynamic theory of public choice behavior, a structure was built that comprised the basic elements of the system under study. Among the basic elements of the study are the

changes in the population size of the local community, the changes in the satisfaction characteristic of the median voter, and changes in the composition of the bundle of products and services available in a community.

B. The Reference Modes

As we mentioned, in public choice economic studies there are a number of models that try to explain voting dynamics and the way these dynamics play out in the long run. The median-voter model describes long-term behavior as the result of the set of preferences of the median-voter that 'dominates' the voting process at any given time. One of the implications of the model is that 'equilibrium' is met when the median-voter preferences are met[2]. The Tiebout hypothesis describes long-term behavior as one of equilibrium too. According to the Tiebout hypothesis, individuals will 'vote with their feet' until each community has become relatively homogenous and contains its optimum number of residents. These 'relatively homogenous' communities would attract more citizens of the same profile and would repel citizens of different profile by means of the 'bundle' of goods and services provided by the government. In these homogenous communities, the citizens would prefer the same type of government output and the government would tend to produce that output to remain in power via the vote of the median-voter-type citizen. Based on the assumptions and implications inherent in the literature surrounding the median voter model and the Tiebout hypothesis, Figure 2 presents reference modes[3] for which our new and integrated model is based on.

[2] Unless the assumption of single-peaked preferences are not met and cycling behavior is exhibited

[3] Reference modes are a set of graphs and other descriptive data showing the development of the problem over time. Sterman, John D. (2000). Business Dynamics: Systems Thinking and Modeling for a Complex World. Boston MA, Irwin McGraw-Hill. (p. 90)

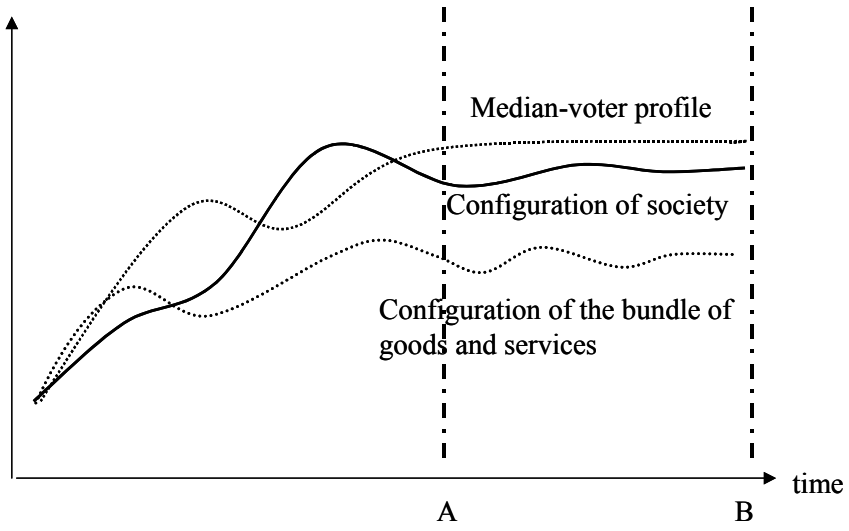


Figure 2—Equilibrium-reaching Reference Modes

If their assumptions are met, the median-voter model and the Tiebout hypothesis tell stories about stability and equilibrium of voting processes, migration patterns, and the composition of the bundles of public goods offered by communities. This theoretical equilibrium is represented in the reference modes in Figure 2. The behavior of the variables during the A-B period is the equilibrium. However, long-term behavior in many societies exhibit cycling characteristics with respect to the 'political orientation' of the society, the 'political orientation' of the majority of the representatives in congresses and parliaments, the 'bundles' of goods and services provided by governments, emphasis in certain public policy issues, etc. Furthermore, the reconfiguration of society continues indefinitely because the 'relatively homogenous' communities tend to change over time causing changes in the median voter profile and the type of goods and services preferred in that community. It seems that the ideal 'equilibrium' described by the median-voter model and Tiebout hypothesis fades over time and reaches a new and different equilibrium exhibiting cyclic behavior. It seems that societies tend to move back and forth between both ends of the political orientation continuum. In the process of moving between the opposite ends of the political orientation continuum, societies continue to pass the 'ideal equilibrium' without settling on it. This is a story about oscillations in the way society behaves over time. However, time delays in society's adjustment to pressures and cycle times make it difficult to actually 'observe' the oscillatory pattern.

Figure 3, below, presents the reference modes from Figure 2 in a long-term picture of the alleged oscillatory behavior of society characteristics. In Figure 3 the behavior represented in the transitional period A-B would be equivalent to the 'equilibrium' period presented in the period A-B in Figure 2. In the case of a larger time frame[4], like the one depicted in Figure 3, the 'equilibrium' state would reappear over time (time segments A-B and A'-B'). In this case, the equilibrium is a transient state within the oscillatory pattern that can only be identified when a longer time frame is analyzed allowing the oscillation to become apparent. Time horizons of analysis are key to understanding the dynamics of the phenomenon (Sterman, 2000, pp. 90-94; 2002, p. 516).

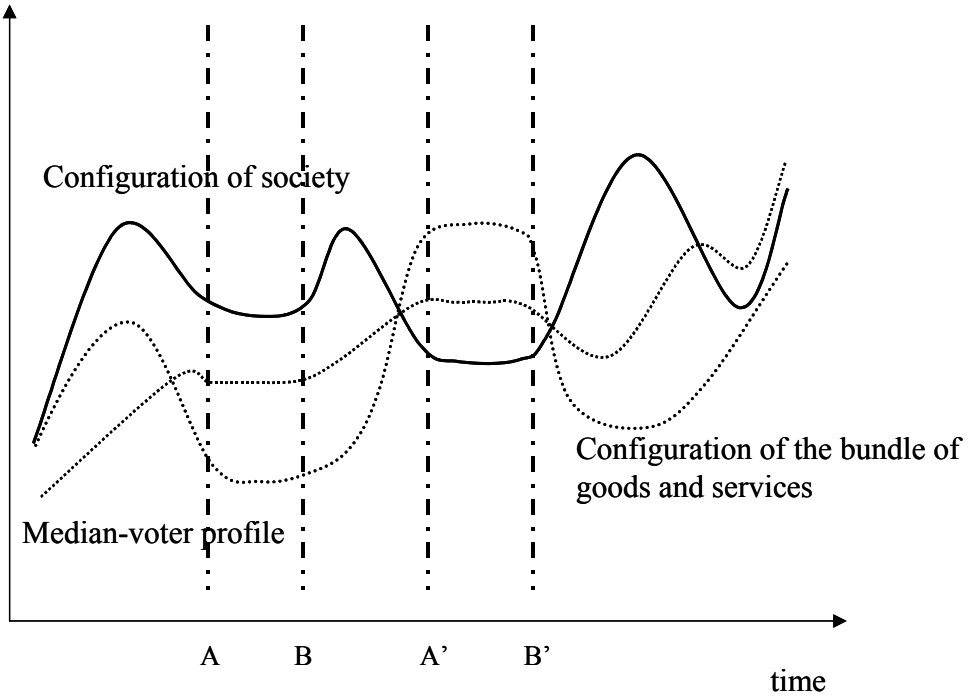


Figure 3—Oscillatory-like Reference Modes

C. The Dynamic Hypothesis

Figure 4, below, shows the dynamic hypothesis of public choice behavior posited in this paper. The dynamic hypothesis is:

[4] The time horizon depicted in Figure 3 could be considered around five times the time period depicted in Figure 3.

Changes in government policies and actions have 'effects' on the population (like migration—voting with your feet—or level of political activity) causing changes in the composition of voters and the configuration of society[5]. These changes in configuration will produce changes in the median-voter profile that, in turn will influence government-decision making. Changes created in the median voter profile create further changes in government policies, actions, and in the production-output configuration or 'bundle' available for citizens. The 'bundle' of public-sector produced services will have an effect on migration patterns that will create further changes in the configuration of society and composition of voters. Ultimately, circular causality is generated by the decisions of the median voter and the government policies over time.

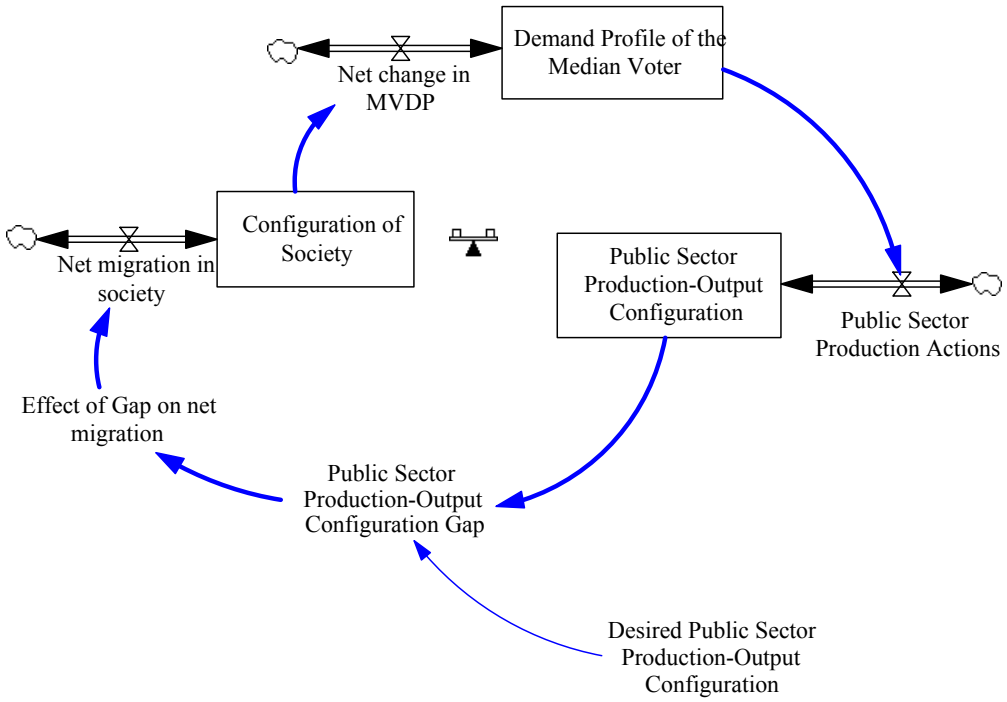


Figure 4—Dynamic Hypothesis of Public-Choice Behavior.

In this model, we are combining the assumptions of the median voter model and the Tiebout model to generate an integrated model of public choice dynamics. As in the Tiebout hypothesis, the way the configuration of society is modeled assumes that there are an infinite number of communities that individuals can go to and can come from.

[5] See Appendix 5 for a glossary of the terms used for the stock variables of the model.

D. The Behavior of the Model

This simulation was conducted for a 50-year period and the model was started in equilibrium representing a 'stable' system. One variable was selected to be used in the analysis, 'individual gap normal.' This variable represents the 'tolerance' level that the median-voter has when he compares his preferences with what the society that he is living in provides. This parameter acts as a normalizing reference for the model. Three different values where chosen, 60%, 9.3%, and below 9.3% of the actual level of production of public goods in that community. The first value, 60%, represents the tolerance level of the average citizen. The second value, 9.3%, represents a citizen with a low tolerance level. The third value, below 9.3%, represents an intolerant citizen. The 'initial' or 'equilibrium' configuration of production of public goods is 10,000 units (complete equations are presented at the end of the paper). To show the generated behavior two graphs are used. The first shows the behavior over time of the three stocks of the model (configuration of society, demand profile of the median voter, and public sector production output). The second shows the behavior in state-state space using public-sector-production-output and demand-profile-of-the-median-voter as focus variables. To force the system out of equilibrium, an exogenous shock of a 10% increase in the desired demand of the public good at time five was implemented. This shock can represent the 'nonconformity' of part of the voters due to a previous decision on the configuration of output of public goods supplied by government.

1. Base Run

Parameters: Individual Gap Normal = 60% of base public sector production-output configuration.

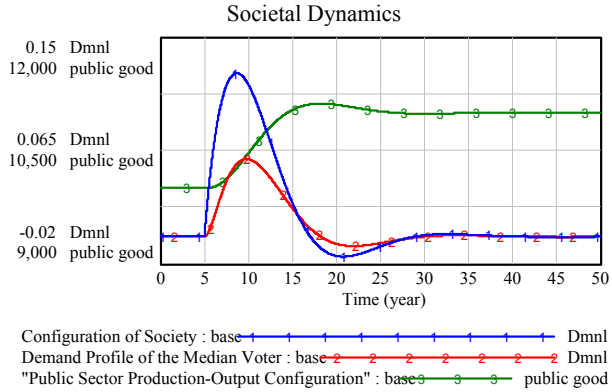


Figure 5—Public choice Dynamics—Base Run

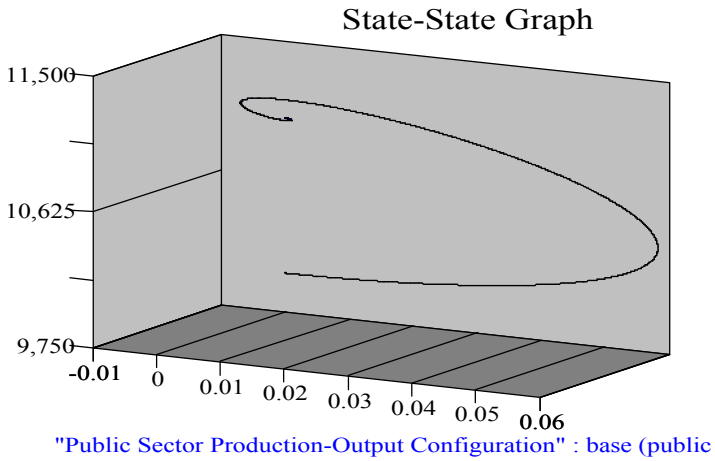


Figure 6—State-State Graph—Base Run

When we assume in the model that the median voter normalizing tolerance is 60 % of the actual configuration of public good, we get an oscillatory pattern (after the exogenous shock to push the system away from equilibrium) that reaches stable equilibrium at a new level of configuration output for the public-sector produced goods and services. Stable equilibrium is reached when 9.3% <'individual gap normal'< 100%.

2. The Structure-Behavior Couple of the Model

In this section, we use the pathway participation metric approach (Mojtahedzadeh, 1996) with Digest to understand the relationship between the structure and the behavior of the initial model of public choice theory. Appendixes three and four present the full structure of the initial model created and the final model that includes a structural change from the previous one.

We created a Table that shows the prominent structures (Mojtahedzadeh, 1996) over time *for Public sector production outcome configuration*. Prominent structures can be defined as the piece of the structure that contributes most to the observed behavior during a particular time period. We decided to trace the prominent structures of the outcome of the public sector because it represents what the citizenry is receiving over time and respond to. Table 1, below, show the results of the prominent structures that drive the behavior—shown in Figure 3—of the model.

Phase	Time	Prominent Structure
1	0.00 to 5.01	No dynamics
2	5.02 to 6.33	Minor balancing loop in configuration of society
3	6.34 to 9.27	Minor balancing loop in demand profile of the median voter
4	9.28 to 9.65	Major balancing loop of the model involving the three stocks
5	9.66 to 9.97	Minor balancing/reinforcing loop in public sector output configuration
6	9.98 to 12.55	Major balancing loop of the model involving the three stocks
7	12.56 to 13.71	Minor balancing loop in configuration of society
8	13.72 to 21.42	Minor balancing loop in demand profile of the median voter
9	21.43 to 21.95	Major balancing loop of the model involving the three stocks
10	21.96 to 21.98	Minor balancing/reinforcing loop in public sector output configuration
11	21.99 to 24.52	Major balancing loop of the model involving the three stocks
12	24.52 to 25.70	Minor balancing loop in configuration of society
13	25.70 to 33.33	Minor balancing loop in demand profile of the median voter
14	33.34 to 36.45	Major balancing loop of the model involving the three stocks
15	36.45 to 37.62	Minor balancing loop in configuration of society
16	37.63 to 45.25	Minor balancing loop in demand profile of the median voter
17	45.26 to 48.37	Major balancing loop of the model involving the three stocks
18	48.38 to 49.54	Minor balancing loop in configuration of society
19	49.55 to 50.00	Minor balancing loop in demand profile of the median voter

Table 1—Prominent Structures of the Initial Model[6]

As we can see in Table 1, there are 19 changes in prominent structure during the 50 time-period simulations. Some structures are prominent for a very small period of time because Digest (Mojtahedzadeh, 1996) is able to pick up changes in loop dominance that are very small and probably not completely relevant to the study of the structure-behavior couple of the model. However, we present the full set of results from our analysis. Actually, only four structures appear in the results repeating themselves over and over in the process. Table 2 offers a consolidation of the results.

[6] Reinforcing (positive) feedback loops generate growth, amplify deviations, and reinforce change. Balancing (negative) loops seek balance, equilibrium, and stasis (Sterman, 2000, p. 111).

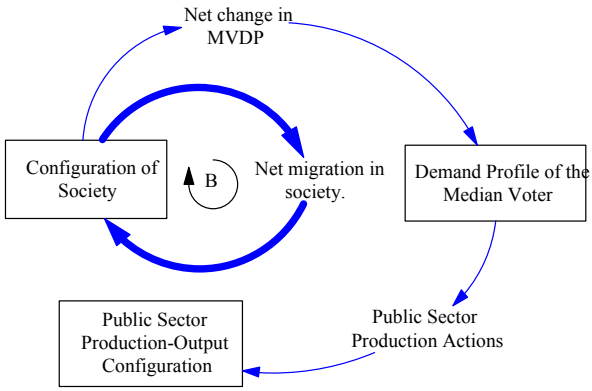
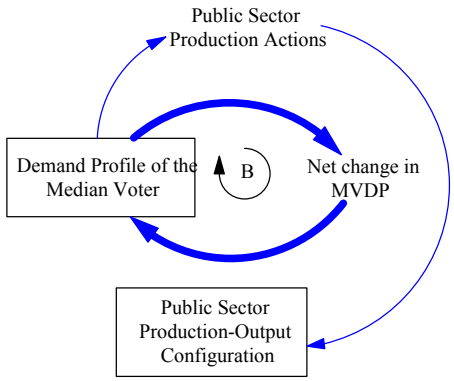
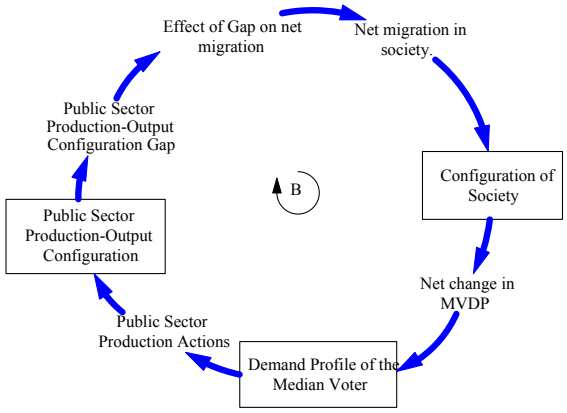
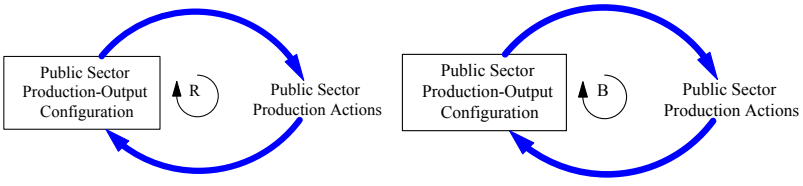
No.	Prominent Structure/Description/Times it becomes prominent	
1	Minor balancing loop in configuration of society 2, 7, 12, 15, 18	
2	Minor balancing loop in demand profile of the median voter 3, 8, 13, 16, 19	
3	Major balancing loop of the model involving the three stocks 4, 6, 9, 11, 14, 17	
4	Minor balancing/reinforcing loop in public sector output configuration 5, 10	

Table 2—Consolidation

Figure 7 presents the way the prominent structures of the model cycle over time. Because the behavior of the model is a cycling behavior, the changes in prominent structure create a closed pattern as presented in Figure 7.

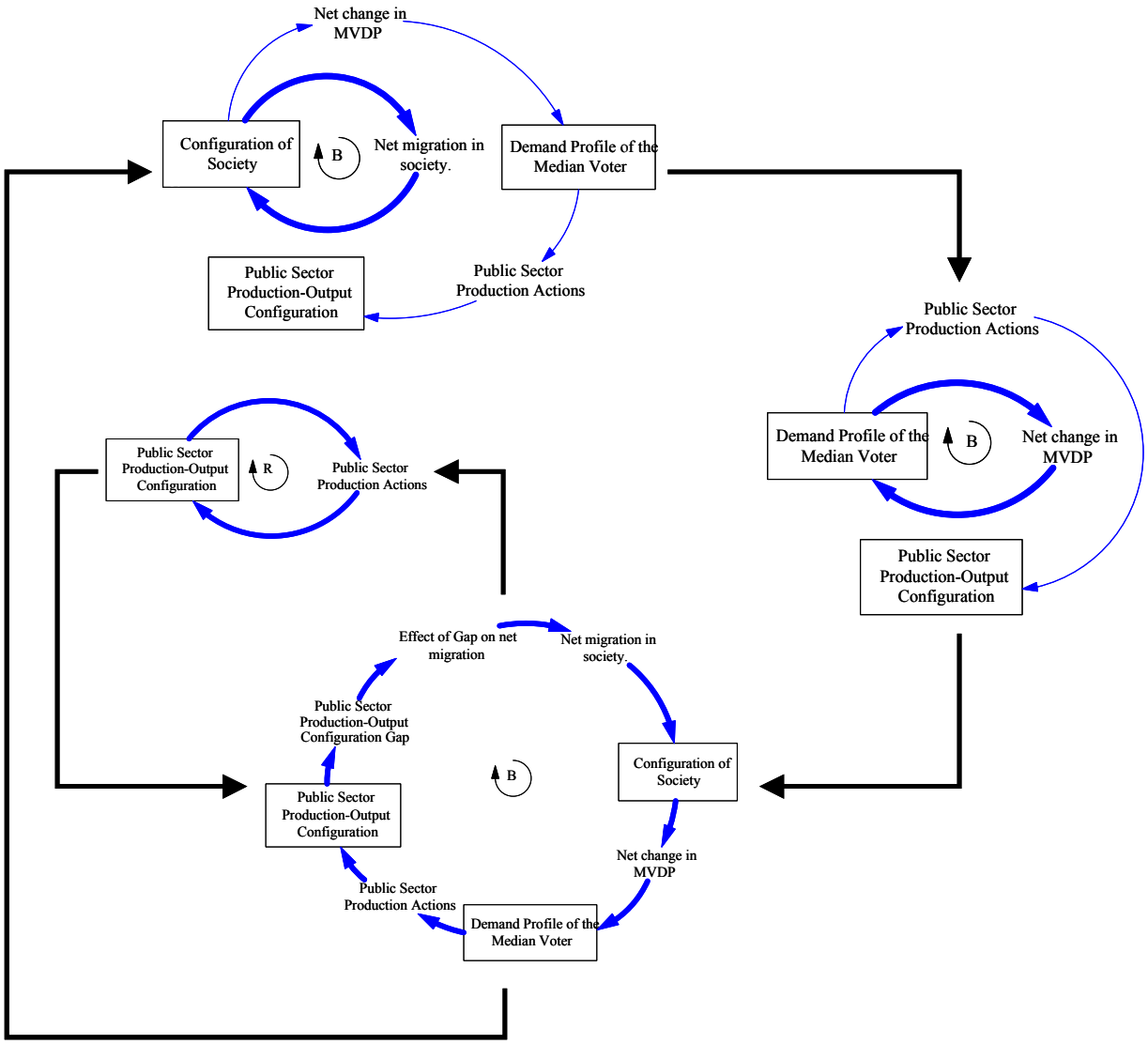


Figure 7—Path of Change in Prominent Structures

If the behavior of the model were a damped oscillation, then the prominent structure would stop cycling and would 'stay' in equilibrium. In the case of sustained oscillation, the prominent structure will show a sustained cycling over time too. Also, in the case of expanding oscillations, the observed behavior of the prominent structure changes would be cycling. The initial prominent structure detected by Digest

after the equilibrium state is highly influenced by the fact that we chose to 'shock' the system and push it out of equilibrium with a change in the '*desired public sector production-output configuration*' variable causing the initial pressure to be absorbed or 'felt' by the minor balancing loop related to 'configuration of society'. This initial 'dominance' should not be understood as anything different than just the receiver of the initial shock to the system. Now we will present new simulation runs of the integrated model to explore the effects of changing certain assumptions made in this model.

3. Less Tolerance Run

Parameters: Individual Gap Normal = 9.3% of base public good per year.

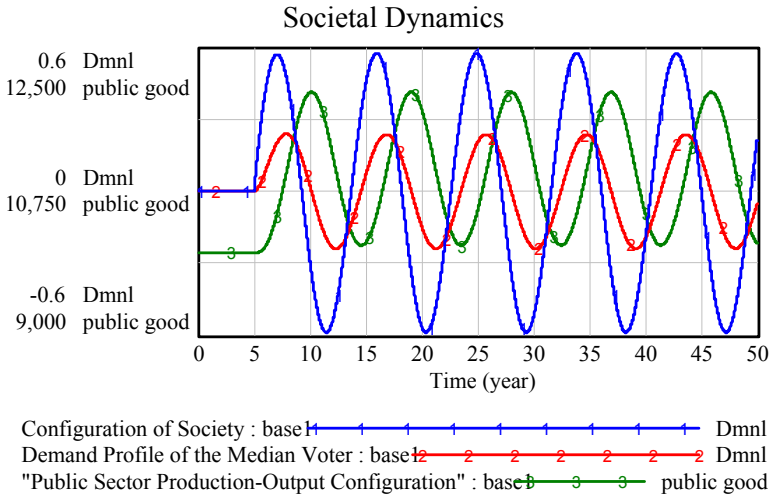


Figure 8—Public Choice Dynamics Less Tolerance Run

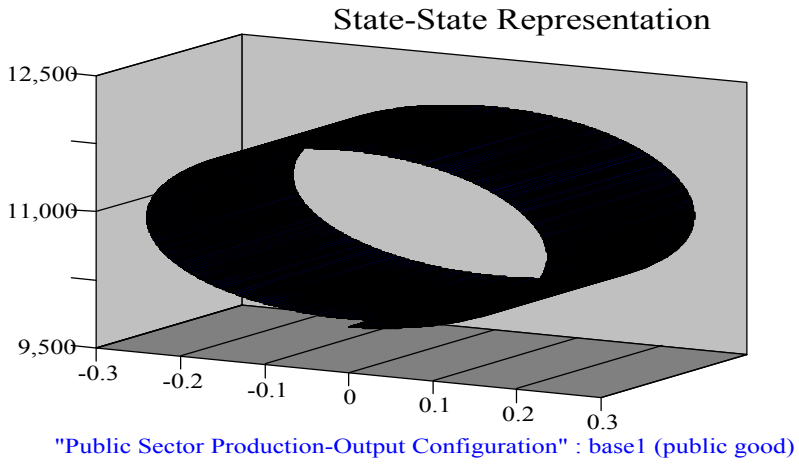


Figure 9—Public Choice Dynamics Less Tolerance Run (State-State)

When we assume that the normalizing gap has a 9.3% difference from the configuration of public-sector goods and services offered, the behavior observed is that of sustained oscillations in the system. As we can see in the state-state representation of the behavior, a cycle appears and it would seem as if the median voter would be favoring different states over others creating the illusion of intransitivity. The reality is that in this state-state representation we cannot 'see' the time dimension. This type of oscillation can explain the behavior exhibited in many systems in which moving thresholds exist. An example can be the changes in political orientation over time in the United States; the balance of power changes from democrats to republicans over time.

4. Intolerant Citizen Run

Parameter: Individual Gap Normal < 9.3% of base public good configuration.

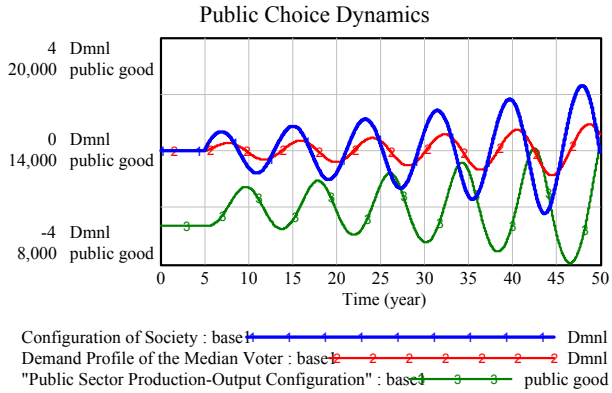


Figure 10—Public Choice Dynamics Intolerant Citizen Run

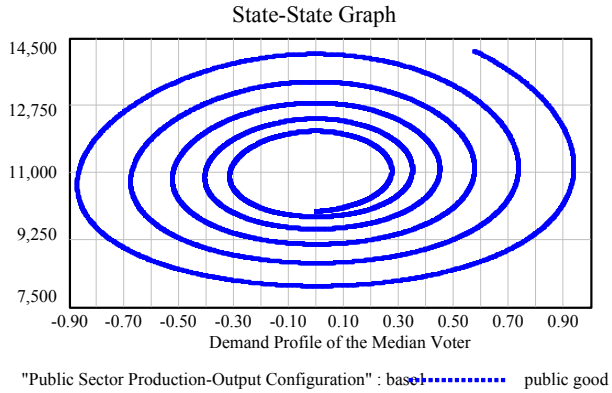


Figure 11—Public Choice Dynamics Intolerant Citizen Run (State-State)

When we assume that the normalizing gap has a 9.3% difference from the configuration of public-sector goods and services offered, the behavior observed is that of sustained oscillations in the system. As we can see in the state-state representation of the behavior, a cycle appears and it would seem as if the median voter would be favoring different states over others creating the illusion of intransitivity.

When we assume a normalizing difference tolerance level of 7.5% to the configuration of public sector output, the behavior exhibited is expanding oscillations. Expanding oscillations throw the system away from equilibrium into an explosive pattern of behavior that is unbounded and will continue growing. Highly volatile and polarized environments could fit this kind of behavior. This kind of behavior, in reality, will have a natural ceiling for the oscillations. The limit could be a violent rupture of the political system like a revolution, civil war, etc.

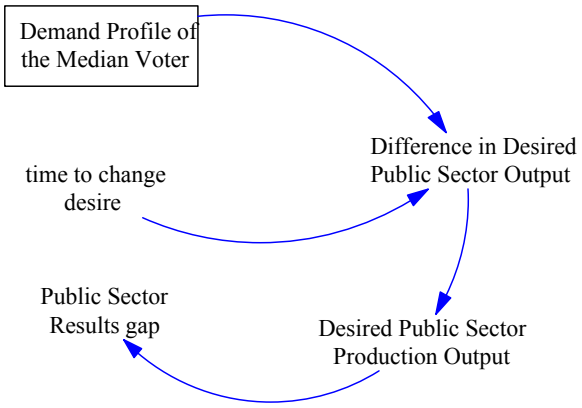


Figure 12—Structural Change

In order to explore additional implications of the model, a structural change is made to create a link between the median-voter profile and the desired public-sector-production output configuration. This link recognizes the influence of the 'new' median voter on the aggregated 'expectations' of voters as a whole with respect to the public sector production output configuration. Up to now, the aggregated 'expectation' of the voters was constant even with a changing median-voter profile. Figure 12 shows the added structure.

The new 'time to change desire' captures the delay between the changed median-voter profile and the expressed new desires that influence the 'effect on migration' on the society configuration. Put

differently, it is the time that people take to decide on doing something (like migrating or becoming politically active/inactive) as a response to the configuration of the output of public goods experienced. Three levels of this time where tested with a 60% level of 'individual preferences normal'. The time used for the base run is one year.

5. Changing Desires Base Run

Parameter: Individual Gap Normal = 60% of base public good configuration and time to change desires set to one year.

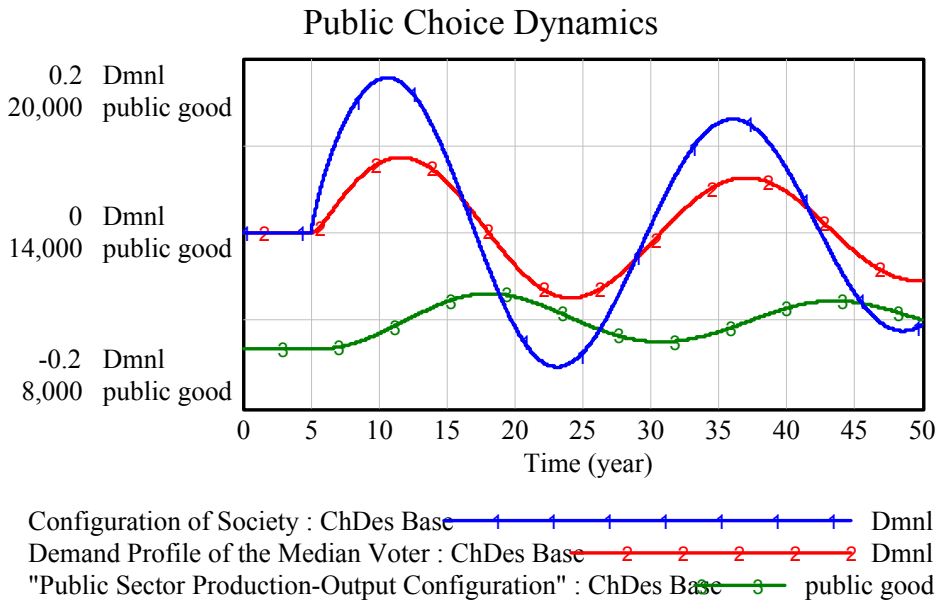
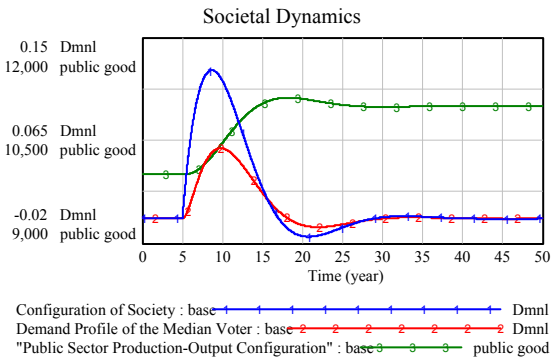
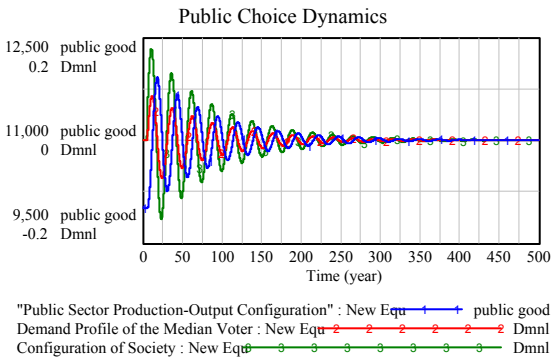


Figure 13—Public Choice Dynamics Changing Desired Base Run

When we endogenize the generation of desires in the simulated society we see less stability in the behavior obtained than with an exogenously considered constant desires for the community (originally set to 10,000 units). Figure 13 shows the behavior.



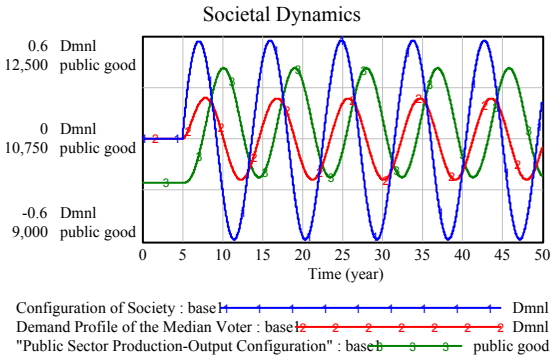


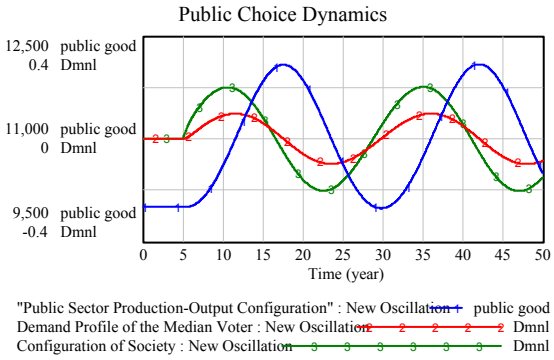
A—Individual Gap Normal 9.3%

B—Individual Gap Normal 54%

Figure 14—Public Choice Dynamics Comparative Base Runs

Figure 14-A shows the equilibrium obtained approximately 25 years after the shock in a society with fixed desires and citizens with little tolerance to changes (individual gap normal=9.3%). However, when we endogenize the desires, a stable equilibrium can be found after 250 years and with a mix of citizens less strict (individual gap normal = 54%).





A—Individual Gap Normal 9.3%

B—Individual Gap Normal 54%

Figure 15—Public Choice Dynamics Comparative Base Runs

Changing the way we modeled the desires of the community changes the observed behavior dramatically. Figure 15 shows that by using exogenous desires of the community, a ‘stable’ cycling equilibrium with a period of approximately 8 years with strict citizens can be achieved. However, when

we endogenized the desires, the 'stable' cycling was obtained with a period of approximately 24 years and with citizens with higher tolerance to changes (individual gap normal = 54%).

6. Changing Desires with less Tolerance Run

Parameter: Individual Gap Normal = 50% of base public good configuration and time to change desires set at one year.

In this run we changed the level of tolerance of the citizens of this community to a lower level than in the base run—from 60% to 50%. This tries to capture the changes that, on average, the community will experience with respect to how much are they willing to 'let go' of what they expect from the bundle of goods and services received. Figure 16 shows the resulting behavior.

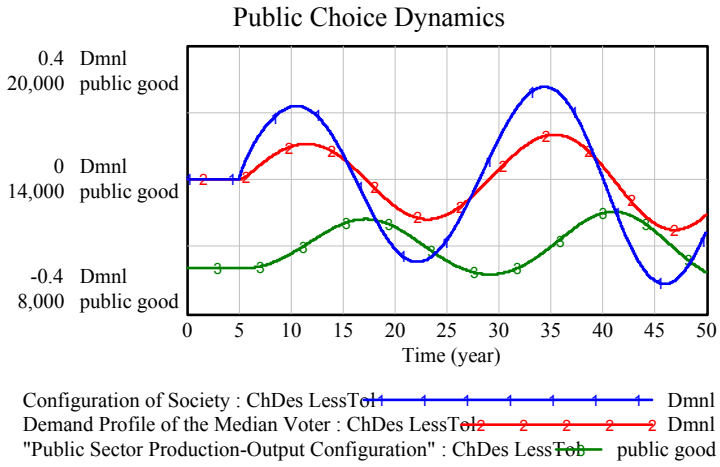


Figure 16—Public Choice Dynamics Changing Desires with Less Tolerance Run

The behavior obtained is expanding oscillatory behavior. This is a result that resembles communities that are not stable and tend towards disequilibria in the long run. However, social systems have balancing mechanisms to control for expanding types of behavior. The expanding tendency identified in this 50-year period would be balanced out by a new feedback mechanism not captured in this model.

A total rupture of the social system of the community is highly unlikely to happen in reality. One insight generated by this run is that the 'carrying capacity' of this community is highly affected by the

combination of endogenously generated desires and the level of tolerance of the citizens in the community.

We could say that, based on these model results, in order to elevate the stability of a community you can either 'select' somehow 'tolerant' citizens or keep the overall expected desires constant or disconnected from the configuration of the median voter. One way to 'disconnect' desires from the configuration of the median voter could be by using a government-influenced declaration of expectations for that community for the long run (e.g. long term development plans for the community).

Another way to 'disconnect' desires with the population profile can be by adding a delay to the recognition of the changes in the desires (in the model we changed *time to change desires* from one year to two years while maintaining the level of tolerance at 50%). The resulting behavior—shown in Figure 17—illustrates the tendency towards a stable equilibrium in the long run. The time to achieve this equilibrium seems long but the tendency exists.

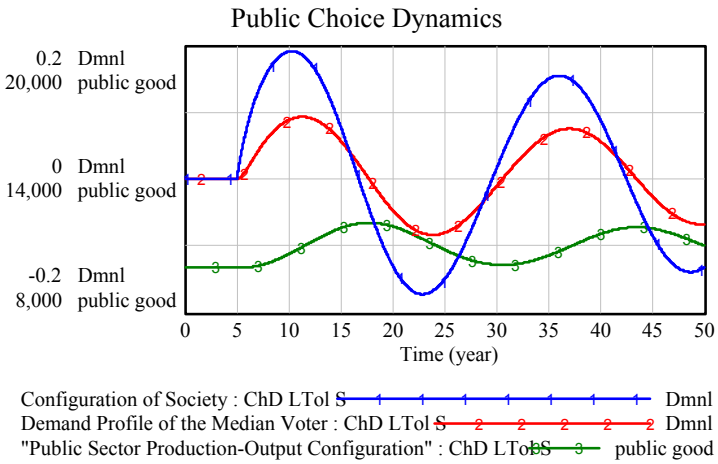


Figure 17—Public Choice Dynamics Changing Desires Time 2

The results found here are basic and preliminary in the sense that the model used is a dynamic hypothesis of voting behavior. The model needs to be developed further, tested extensively and grounded in theory and empirical data to gain confidence in the findings presented here. The political actors, while

trying to please the median voter, are creating the conditions in the environment for the median-voter change over time. They are causing the changes in the system that can lead to stability/instability.

III. Conclusions and Directions for Future Research

This paper opens up several directions for future research. First, additional economic models may be included in this dynamic model. For example, exploring Downs's (1957) economic theory of democracy and Stigler's economic theory of regulation may provide additional implications for the structure and behavior of the integrated model. Second, the mechanisms that can smooth out the oscillations and help to generate equilibrium in society explored here can be seen as careful-planning procedures by some, but as undemocratic actions by others. Further exploration of the model implications is necessary to adequately substantiate these claims.

This paper presents some considerations in the use of the median voter model and the Tiebout hypothesis. The classic way of looking at the model is from a 'static' standpoint. When a 'dynamic' view is used, the long-term picture is clearer. With a dynamic view of the voting process we can create links among two public choice models, the median voter model, the Tiebout (1956) model. A dynamic view suggests that the public 'demand' captured by the median voter model will be transformed into public supply by the political forces to please the median voter and, by doing so, maximize the likelihood of the political actors continuing in power. The actions taken by political forces to generate the supply of public goods and services will generate observable consequences that will influence the citizenry to act rationally to maximize the chances of having their set of preferences satisfied. The citizen actions in response to the government actions can take a variety of forms. Two are of interest here. Citizens can choose to leave the community and go to another community where their set of preferences belong to that of the median voter and are satisfied (Tiebout, 1956), or they can become more politically active participants and try to influence other voters (Downs, 1957). Either of these forms will change the characteristic profile of the median voter of that community. In both of the two possibilities the net effect is that the composition of society is changed, and over time, influences the profile of the median voter.

The fact that the legislature and government will find a 'different' median voter over time is not considered in any of the models presented. This 'new' median voter will generate a 'new' public demand that government will supply generating 'new' consequences that will generate even more changes in the median voter profile. This means that by giving to the median voter what he or she wants, government is endogenously influencing the creation of a different median voter over time. The changes in the median voter profile are endogenous and caused by the structure in which the voters, government, and political actors are immersed. All actors involved are behaving rationally according to their maximizing rules, and by doing so, are creating the changes in voting patterns, migration choices, and public sector supply and demand that societies face.

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Appendix 1 Model (Initial) Vensim Equations

```
********************************
  .Control
********************************
FINAL TIME  = 50 Units: year
INITIAL TIME  = 0 Units: year
SAVEPER  = TIME STEP Units: year
TIME STEP  = 0.0078125 Units: year
********************************
  .Dynamic mvmodel last-one
********************************
1       Average Time to Adjust Profile= 1
        Units: year
2       Configuration of Society= INTEG (Net migration in society,0)
        Units: Dmnl
3       Contribution of society configuration to median voter profile= 0.5
        Units: Dmnl
4       Demand Profile of the Median Voter= INTEG (+Net change in MVDP,0)
        Units: Dmnl
5       "Desired Public Sector Production-Output Configuration"="Eq Public Sector Production-Output
        Configuration"*(1+Exogenous Change in Output) Units: public good
6       Effect of Gap on net migration= "Public Sector Production-Output Configuration Gap"/Individual Gap
        Normal Units: Dmnl
7       "Eq Public Sector Production-Output Configuration"= 10000
        Units: public good
8       Exogenous Change in Output= STEP(Size of change, Time to change)
        Units: Dmnl
9       Gap tolerance= 0.6
        Units: Dmnl
10      Individual Gap Normal= Gap tolerance*"Eq Public Sector Production-Output Configuration"
        Units: public good
11      Net change in MVDP= ((((Configuration of Society)*Contribution of society configuration to median voter
        profile)-(Demand Profile of the Median Voter))/Average Time to Adjust Profile)
        Units: Dmnl/year
12      Net migration in society=(Effect of Gap on net migration-Configuration of Society)/Time to Adjust
        Configuration via migration Units: Dmnl/year
13      Public Sector Average Time to Act=3
        Units: year
14      Public Sector Production Actions=("Public Sector Production-Output Configuration"*Demand Profile of
        the Median Voter*Public Sector Responsiveness to the Median Voter Profile)/Public Sector Average Time
        to Act Units: public good/year
15      "Public Sector Production-Output Configuration"= INTEG (+Public Sector Production Actions, "Eq Public
        Sector Production-Output Configuration") Units: public good
16      "Public Sector Production-Output Configuration Gap"= "Desired Public Sector Production-Output
        Configuration"-"Public Sector Production-Output Configuration" Units: public good
17      Public Sector Responsiveness to the Median Voter Profile= 0.75
        Units: Dmnl
18      Size of change=0.1
        Units: Dmnl
19      Time to Adjust Configuration via migration= 2
        Units: year
20      Time to change=5
        Units: year
```

Appendix 2 Model (Final) Vensim Equations

```
********************************
  .Control
********************************
(02)    FINAL TIME  = 50
        Units: year
(03)    INITIAL TIME  = 0
        Units: year
(04)    SAVEPER  = TIME STEP
        Units: year
(05)    TIME STEP  = 0.0078125
        Units: year
********************************
  .Dynamic mvmodel last
********************************
(07)    Average Time to Adjust Profile=1
        Units: year
(08)    Configuration of Society= INTEG (Net migration in society,0)
        Units: Dmnl
(09)    Contribution of society configuration to median voter profile=0.5
        Units: Dmnl
(10)    Demand Profile of the Median Voter= INTEG (+Net change in MVDP,0)
        Units: Dmnl
(11)    "Desired Public Sector Production-Output Configuration"="Eq Public Sector Production-Output
        Configuration"*(1+Exogenous Change in Output+"Difference in Desired Public Sector Production-Output
        Configuration")
        Units: public good
(12)    "Difference in Desired Public Sector Production-Output Configuration"=SMOOTH(Demand Profile of the
        Median Voter, Time to change desire)
        Units: Dmnl
(13)    Effect of Gap on net migration="Public Sector Production-Output Configuration Gap"/Individual Gap
        Normal
        Units: Dmnl
(14)    "Eq Public Sector Production-Output Configuration"=10000
        Units: public good
(15)    Exogenous Change in Output=STEP(Size of change, Time to change)+STEP(-Size of change, Time to
        change+1)
        Units: Dmnl
(16)    Gap tolerance=0.18
        Units: Dmnl
(17)    Individual Gap Normal=Gap tolerance*"Eq Public Sector Production-Output Configuration"
        Units: public good
(18)    Net change in MVDP=((((Configuration of Society)*Contribution of society configuration to median voter
        profile)-(Demand Profile of the Median Voter))/Average Time to Adjust Profile)
        Units: Dmnl/year
(19)    Net migration in society=(Effect of Gap on net migration-Configuration of Society)/Time to Adjust
        Configuration via migration
        Units: Dmnl/year
(20)    Public Sector Average Time to Act=3
        Units: year
(21)    Public Sector Production Actions=("Public Sector Production-Output Configuration"*Demand Profile of
        the Median Voter*Public Sector Responsiveness to the Median Voter Profile)/Public Sector Average Time
        to Act
```

Units: public good/year

(22) "Public Sector Production-Output Configuration"= INTEG (+Public Sector Production Actions,"Eq Public Sector Production-Output Configuration")
Units: public good

(23) "Public Sector Production-Output Configuration Gap"="Desired Public Sector Production-Output Configuration"-"Public Sector Production-Output Configuration"
Units: public good

(24) Public Sector Responsiveness to the Median Voter Profile=0.75
Units: Dmnl

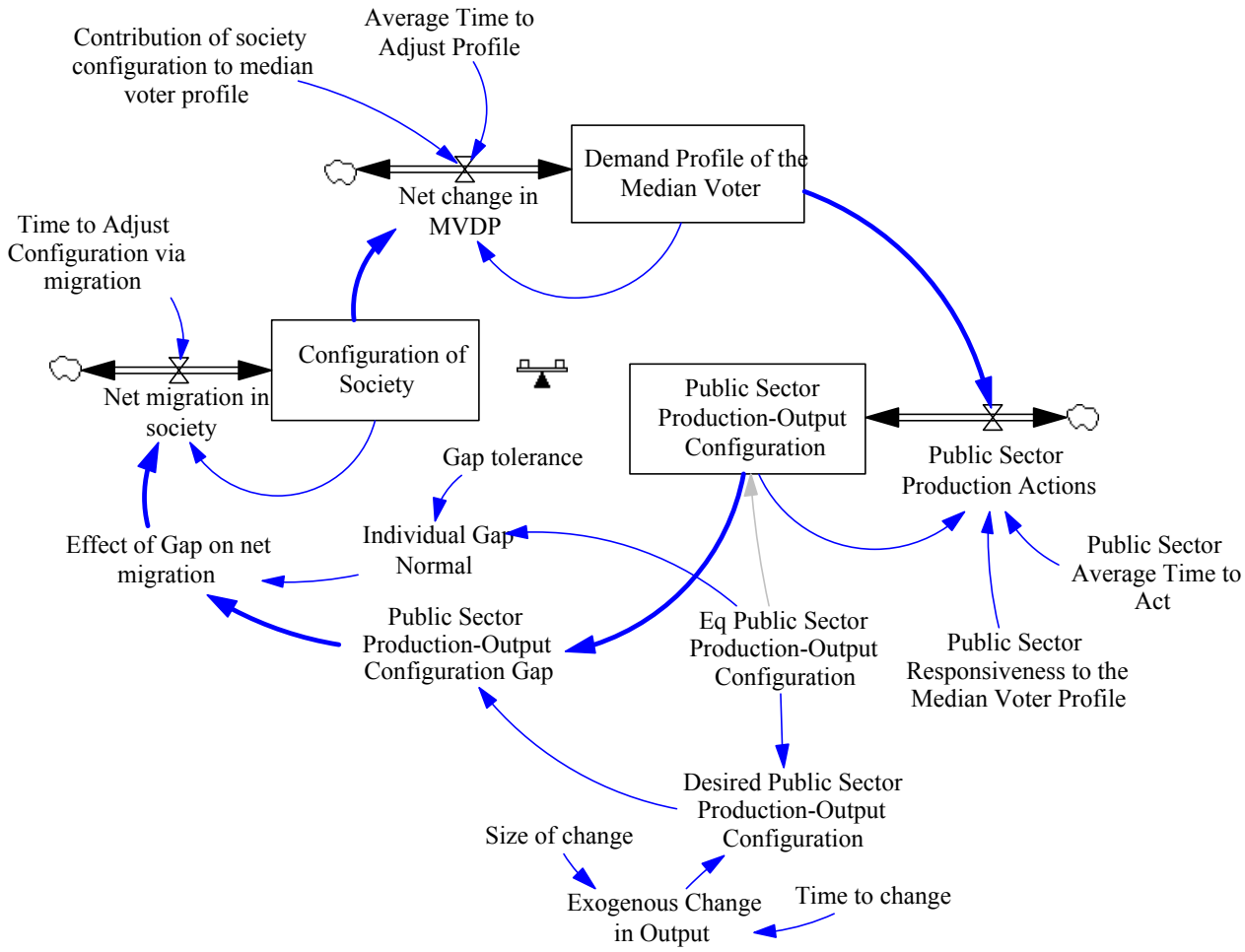
(25) Size of change=0.1
Units: Dmnl

(26) Time to Adjust Configuration via migration=2
Units: year

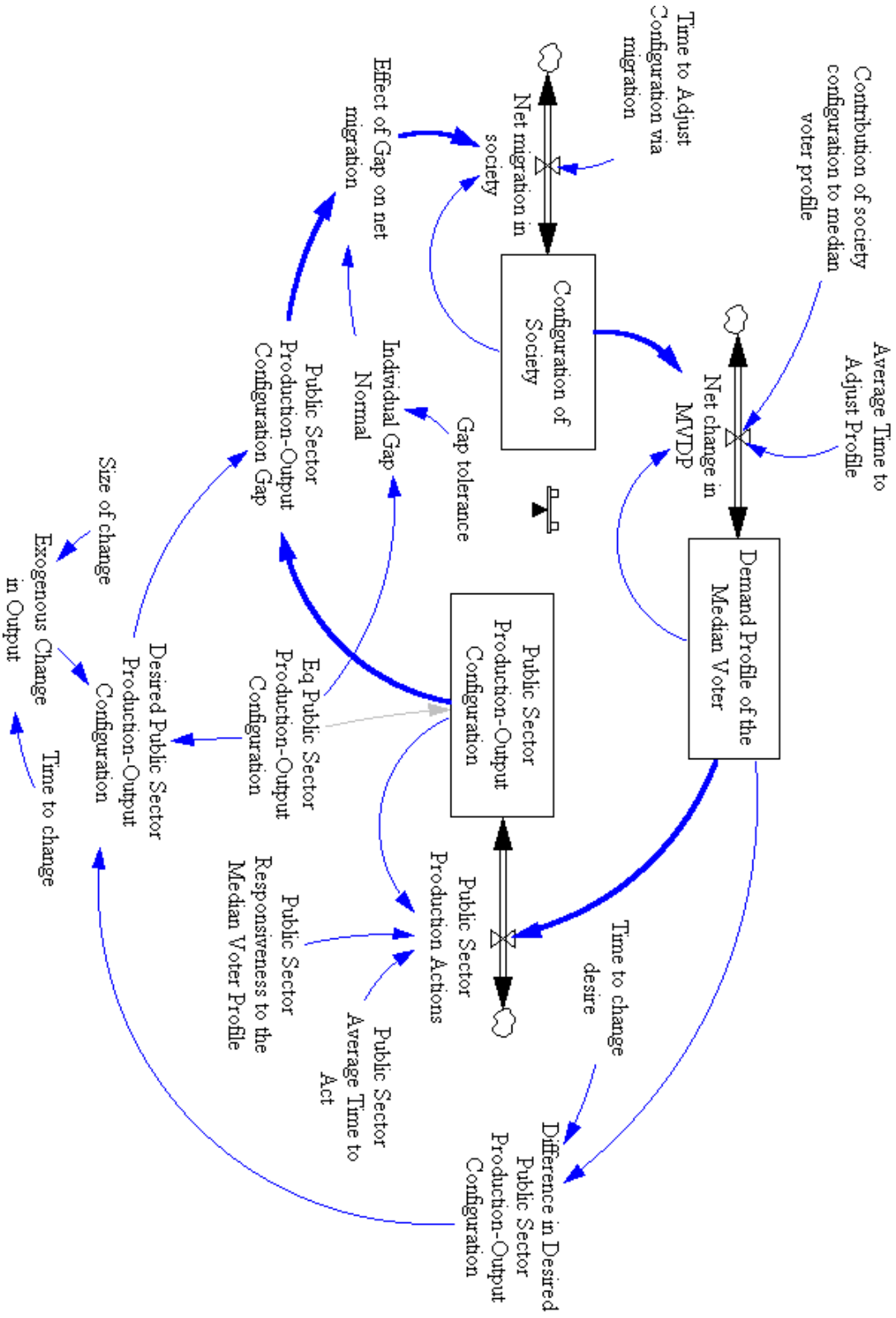
(27) Time to change=5
Units: year

(28) Time to change desire=5
Units: year

Appendix 3 Model Structure (Initial)



Appendix 4 Model Structure (Final)



Appendix 5 Glossary

Accumulations (Stock Variables)

Configuration of Society — Changes in size of the community relative to the original size. Size refers to the number of individuals living in the community.
This variable is initialized at zero. Zero is equal to the original size of the community under study. Therefore, if the variable changes from 0.0 to 0.10 it represents a 10% difference in the size of the community relative to its original size.

Demand Profile of the Median Voter—Changes in the configuration of the median voter 'satisfaction' profile. This refers to the median voters level of satisfaction with the bundle of public goods available in a community.
This variable is initialized at zero. Zero is equal to the original profile of the median voter in the community. Therefore, if the variable changes from 0.0 to 0.10 it represents a 10% difference in the profile.

Public Sector Production-Output Configuration—The bundle of products and services that a community offers to its citizens.
This variable is initialized in 'equilibrium' at 10,000 units. These 'bundle' units represent the 'score' that the bundle gets when ranked against other bundles of other communities by each individual voter. Changes in the relative score means changes in the bundle of products and services provided by the public sector in charge of the community. If this variable goes up it does not necessarily mean that the government produces 'more' output but changes the configuration of it making the overall attractiveness of the bundle higher for the citizens.

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