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INDIVIDUAL CHOICE AND PUBLIC POLICY IN THE UNITED STATES

By

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ABSTRACT

INDIVIDUAL CHOICE AND PUBLIC POLICY IN THE UNITED STATES

By

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This dissertation considers the role of individual choice as a determinant of public policy and social outcomes. The work is undertaken from the perspective of theoretical macroeconomic models of individual actions. The models themselves are concerned with social security, medical subsidies and electoral choice.

In Chapter 2, I model a system of electorally determined social security taxation, wherein voters, who are differentiated by age and productivity, may choose to vote or abstain, depending on the costs and perceived benefits of participation. It is found that participation rates will vary across class and age groups, and in particular, the middle classes will form a much more coherent political force than their poorer contemporaries.

The Medicare subsidy system is modeled in Chapter 3, wherein agents' decisions about their medical treatment affect both their health and their incomes. We have found that under reasonable circumstances, Medicare spending may not only lower the health and welfare of young agents, but through spillover effects, may also be detrimental to its recipients.

In Chapter 4, I return to a theme examined in Chapter 2, that of alienation. In this chapter, I examine the US Presidential election data for evidence of alienation within the electorate, and find that such evidence exists, and is compelling.

ACKNOWLEDGEMENTS

I would like to thank the members of my dissertation committee for the advice and guidance in the preparation of this work. Above all, I would like to thank Rowena Pecchenino, the chair of my committee, for her unstinting backing, assistance and wealth of support during the course of my dissertation research.

The comments and suggestions of Robert H. Rasche and Jeffrey Wooldridge have been invaluable in focusing and clarifying my research. In particular, their comments with respect to the fourth chapter helped greatly in shaping not only the presentation but also the structure of work.

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Chapter 1. Introduction

This dissertation is concerned with the relationship between individual choices and public policies, as examined from a macroeconomic perspective. It employs theoretical and empirical models of three topics; social security, Medicare and electoral strategy, in order to examine the often unanticipated consequences of individual rationality, as played out on a macroeconomic scale.

Chapter 2 models electorally determined social security taxation within an overlapping generations general equilibrium framework where voters are vulnerable to alienation. Agents are heterogeneous, and decide upon a preferred tax policy based upon their own short-term individual economic self interest and the long-term well-being of their group in society. Given this ideal policy and the policy platforms of political candidates (which are endogenously determined), agents may or may not participate. Through simulation, it is found that older agents and the wealthy are disproportionately likely to participate, and thus wield a disproportionate influence upon the outcome of the election. Furthermore, the more socially motivated agents are, the more centrist the equilibrium tax rate and the less sensitive that tax rate is to changes in the income distribution.

The third chapter deals with the Medicare program, established in 1965 to improve the health care available to elderly Americans. It has achieved this goal, but we question the cost at which this has been achieved. To evaluate this cost, this paper develops an overlapping generations model in which two types, high and low health status/productivity, of two-period lived agents value health for both utility and human capital enhancing reasons. The findings include: (i) a reduction in the price of health care, either directly or via subsidies, for the working population may increase steady-state healthiness of workers and retirees of both types and may increase capital accumulation; (ii) an increase in the Medicare subsidy rate need not improve the steady-state healthiness of retirees, reduces the healthiness of the young and average health, and reduces capital accumulation; and (iii) increasing the elderly's share of the cost of the Medicare system, if financed via lump-sum rather than distortionary taxes, may improve the steady-state healthiness of workers and retirees, and may increase capital accumulation.

Finally, Chapter 4 seeks to test the assumption upon which Chapter 2 was predicated, that agents are likely to be alienated by political candidates of sufficiently low quality, based upon econometric testing of the ICPSR National Election Survey dataset covering the period 1980 to 1988. Using various measures of voter location, either on an absolute scale or relative to the candidates' locations, the voter's sensitivity to candidate placement is tested. It is found that the agent's probability of participation is more sensitive to changes in the location of the preferred candidate than to changes in the policy position of the less-preferred candidate. This is consistent with the hypothesis that voters posses a convex (and hence proximity-sensitive) disutility function over imperfect policy choices. This in turn implies that given uniform costs of participation, voters whose policy bliss points are distant from their preferred candidate are less likely to participate than those whose preferred candidate is close to their ideal, i.e. that voters are susceptible to alienation.

Chapter 2. Alienating the Electorate: A Model of Social Security with Intelligent Voters

Section I: Introduction

In a political system without abstention, where voters all exercise the franchise, the behavior of the individual voter may be modeled as a relatively simple decision, and from that it is a complex, but tractable, task to model the behavior of politicians. If, however, one looks at the U.S., with an electoral system characterized by low participation rates for the even most important of national elections, then the voters' decisions, and the candidates' strategic responses become much less clear-cut.

One of the most promising and persuasive explanations of the low level of turnout observed in many recent elections is that of *alienation*, i.e. that voters are increasingly unlikely to vote for a preferred candidate whose policy position differs greatly from the voter's ideal policy position. These models are based on a spatial interpretation of electoral strategy and behavior, following from the work of Hotelling (1929) and Downs (1957).[1]

Early models (e.g. Hinich and Ordeshook (1969)) based upon alienation have appeal as a partial explanation of low participation rates. Voters face costs of voting, and as such are unwilling to vote for their preferred candidate *irrespective* of that candidate's qualities, or indeed those of the opposing candidate. Thus, when voters feel that the candidates are of sufficiently poor quality, participation falls because few voters see the candidates on offer as being 'worth the effort' of voting.

However, if the agent abstains, this increases the probability that the preferred candidate will lose. As such, the agent must be concerned about not only the benefit to be gained by the success of the preferred candidate, but also the potential loss suffered should th

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should the less preferred candidate win, and hence the difference in utility between the two outcomes. As the preferred outcome becomes better, or the less preferred outcome becomes worse, the likelihood of alienation should decrease.

Thus, more modern literature (such as Anderson and Glomm (1992)) on alienation is predicated upon voters who are alienated by the comparative qualities of the two candidates, rather than merely the location of the preferred candidate.

However, what conventional theoretical models of alienation have not captured as yet, and what this model does indeed find, is an asymmetry in the distribution of alienation found in society under equilibrium conditions. While participation rates are found, of course, to depend on the agent's location relative to the candidates, agents of differing ages and classes will possess different levels of alienation, and hence different participation rates, even if the initial distributions of income and age are symmetric. As such, certain groups wield a share of the vote out of proportion to their share of the population as a whole.

What is not considered here is the "paradox of voting", the question as to why anyone, within a continuum of voters would feel that their impact on the election was sufficient to overcome the costs of participation. This issue has received considerable discussion, but as yet remains unsolved for frameworks within which individual, uncoordinated voters have zero mass relative to the population. Ledyard (1984), has shown that within a continuum of voters, the paradox is effectively unavoidable.

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[1] For discussion of the general nature of spatial electoral games, see Enelow and Hinich (1984) and Enelow and Hinich (1990).

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Instead, it is *assumed* that the voters' level of interest in the election is sufficient that at least some proportion of the electorate will use their franchise regardless of the nature of the electoral competition.

The paper presented here is a model of electorally chosen social security taxation, where not only agents' consumption decisions, but also their decision to participate and the candidates' decisions on policy placement are *all* based upon utility maximization.

Voters in this model are concerned with three issues. Firstly, they consider the economic effects of the proposed tax upon themselves. Secondly, in a mildly altruistic manner, they examine the implications of the tax upon their group in society. Such a combination of self-interest and mild altruism has found some empirical support, e.g. in Hudson and Jones (1994) and Shabman and Stephenson (1994). Lastly, based upon the outcomes of the first two analyses and the candidates' proposals for the tax, they determine whether or not they should take part in the election.

In making this final decision, the voters face both potential utility gains from a preferable outcome of the election, and utility losses from the costs of gathering information concerning the candidates and then voting. As such, based upon the relative utility gains and costs, the agent may choose not to vote, if they are indifferent to the candidate choice presented, or if they are alienated by the lack of quality of the candidates. Agents decide whether or not to vote based upon the difference the choice of candidates has on their combined economic and social utility, as well as upon their proximity to candidates (and hence their likelihood of alienation).

The model uses an overlapping generations framework, with agents distributed into a number of productivity classes. Within each class, there are young and old agents.

This is the only exogenously introduced differentiation between agents in the model. Their preferences and behavioral patterns are in no other way different from one another. Their actions, the actions of the politicians, who are assumed to be solely interested in electoral success, and hence the outcome of the election are all derived from their utility maximizing behavior given age and productivity.

Agents vote on the level of social security taxation to be imposed in a given period, and hence the benefits to be received by the current old and the taxes to fall on the current young. The government may not run a deficit in any period. Thus, unlike models such as those of Cukierman and Meltzer (1989) and Alesina and Perotti (1995), the electoral issue at stake is the level of redistribution between age groups and classes rather than the level of national debt.

The model's conclusions may be summarized as follows. Although most agents possess an economic bliss point for either a zero % tax rate or a 100% tax rate, their concern for the social well-being of their class leads most agents to possess an interior bliss point. Secondly, wealthy agents and old agents are disproportionately likely to participate, and as such have a disproportionate impact on the outcome of the election.

The more economically motivated the agents are (and hence the less socially concerned), the more likely it is that the electoral outcome is determined by age rather than income group, and as such, the more polarized the outcome is. This furthermore implies a high overall level of alienation and low participation.

Likewise, as agents suffer increasing disutility from imperfect candidates, and hence as alienation rises, the result of the election becomes increasingly polarized and participation falls.

The equilibrium level of taxation is found to be sensitive to the nature of the population distribution. However, under mildly restrictive assumptions, the results outlined above persist strongly, and are highly robust.

The paper is organized as follows. The economic and political framework of the model is described in Section II. Section III details the conditions required for equilibrium in such a politico-economic model. Section IV analyses the agent's economic, social and political decisions, and the effects of changes in social security taxation on the level of

bequests, savings and utility. These effects, naturally, alter the bliss points of the agents, as discussed in Section V. The outcomes of the plurality maximizing form of the electoral game are presented in Section VI, followed by conclusions in Section VII.

Section II: The Framework Of The Model

Consider a Diamond (1965) style overlapping generations model comprised of two-period lived agents, firms, and single-period lived politicians. There are n types of agents, $i = 1,...,n$. At each date t, $N_i(t)$ young agents of type i are born. There is no population growth.

Agents belong to groups or classes, which differ in productivity. A type i agent has productivity h_i, where $h_i < h_j$ for $i < j$. Agents of all types supply their labor inelastically to firms when young, and divide their after tax wage between savings and consumption. They also may or may not vote. In their age, agents consume from the returns on their savings and a uniform social security payment, less any bequest they make, and they also may or may not vote.

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Agents decide whether or not to participate in each election based upon their economic and social sensitivity to the potential outcomes, their information level concerning the effects of those outcomes, and their costs of participation. Their level of interest in the outcome of the election is based upon the direct economic effect of the tax rate on the agent as well as upon the effect of the tax rate on the long term well-being of the representative agents from the voter's own productivity class.

Agents' Utility

Each agent needs to solve three problems in order to make his full political decision. Firstly, the agent needs to solve the dynamic constrained maximization problem so as to determine how taxation will directly affect his economic well-being. Secondly, the agent must determine the solution of the steady state maximization problem for a member of his class, so as to determine how taxes will affect the social welfare of his group. Thirdly, the agent must maximize political utility over the participation decision by determining whether or not the costs and benefits to participation are such as to make participation itself worthwhile.

Economic preferences are defined over the consumption (when young and when old) of the individual and the value placed upon bequests given to the members of the next generation.

$$U_{Eit} = Ln[c_{it(t)}] + \beta\ Ln[c_{it(t+1)}] + \delta\ Ln[B_{it(t+1)}]$$

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where $c_{it(t)}$ is the level of consumption of a member of class i of generation t at time t, $c_{it(t+1)}$ is the consumption of a member of class i of generation t at time t+1 and $B_{it(t+1)}$ is the bequest made by a member of class i of generation t at time t+1.

Consumption when young is constrained by after tax income, less savings, plus any bequest received. Bequests are class-specific, so members of a given group receive a bequest from *their* direct predecessors, rather than from the population as a whole.

$$c_{it(t)} = w_{it} (1 - \tau_t) - s_{it} + B_{it-1(t)}$$

[2.2]

Consumption when old is constrained by income from previous savings, less any bequest given, plus a social security payment. The social security payment is equal to a proportion (ε_{t+1}) of the *average* level of wages in a given period (w_{At+1}).

$$c_{it(t+1)} = s_{it} (1 + r_{t+1}) + \varepsilon_{t+1} w_{At+1} - B_{it(t+1)}$$

[2.3]

The agent also derives utility from the welfare of his class. This utility is determined by the economic utility of agents of the voter's own type, in steady state. In this role, the agent acts as a form of social planner, although the agent's view of society solely considers the interests of his own group.

$$U_{Sit} = Ln[c_{iy}] + \beta Ln[c_{io}] + \delta Ln[B_i]$$

where

$$c_{iy} = w_i (1 - \tau) - s_i + B_i$$

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$$c_{io} = s_i (1 + r) + \varepsilon w_A - B_i$$

[2.4]

Thus, the agents political preference for taxation is defined by a weighted political utility function, U_{Pit}, comprising both economic and social utility:

$$U_{Pit} = \zeta U_{Eit} + (1 - \zeta) U_{Sit}$$

[2.5]

The agent must then choose whether or not to participate, based upon the difference in political utility (ΔU_{Pit}) which arises from the difference in candidate tax manifesto positions (i.e. the comparison of utility under one manifesto tax rate versus under the other), as well as the cost of information (I_{Pit}) and explicit costs of voting (γ_{ij}). Thus, the participation of an individual j of type i is dependent on ΔU_{Pit}, I_{Pit} and γ_{ij}.

$$P_{ij} = P_{ij}\left(\Delta U_{Pit}, I_{it}, \gamma_{ij}\right)$$

[2.6]

Firms

Firms in the economy are perfectly competitive and employ a CRS production function, the inputs to which are capital (which completely depreciates each period) and effective labor, which is the sum of the quantity of labor in each class multiplied by the per capita efficiency of that class:

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$$Y_t = K_t^{\alpha} (N_1 h_1 + N_2 h_2 + \ldots + N_n h_n)^{(1-\alpha)}$$

[2.7]

where N_i is the number of workers of type i the firm hires, i = 1,...,n, and h_i is the productivity level of an agent of type i. K_t is capital at time t, and Y_t is output at time t.

In per capita terms:

$$y_t = k_t^{\alpha} (\theta_1 h_1 + \theta_2 h_2 + \ldots + \theta_n h_n)^{(1-\alpha)}$$

$$y_t = k_t^{\alpha} h_A^{(1-\alpha)}$$

[2.8]

where h_A is the average level of productivity of society, normalized to 1, and θ_i is the proportion of type i agents in society.

Capital markets are competitive, and thus capital is paid its marginal product.

$$(1 + r_t) = \rho_t = \alpha k_t^{\alpha-1}$$

[2.9]

From profit maximization, wages are equal to the marginal product each class' labor.

$$w_{it} = (1 - \alpha) h_i k_t^{\alpha}$$

[2.10]

These two conditions are also factor market clearing, as young agents supply their labor inelastically and old agents supply their saving inelastically.

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The Government

The government collects income taxes from the young (at a uniform rate of income tax), and pays a uniform social security benefit to the old. This governmental behavior represents the role of an redistributionary income transfer from the young to the old, so no taxation is placed on capital (and hence upon the old) for simplicity.

$$\tau_t \sum_{i=1}^{n} \theta_i w_{it} = \varepsilon_t \, w_{At}$$

[2.11]

The government must run a balanced budget, and may not borrow to cover its outflows.

Goods Market Clearing

The goods market clearing condition requires that all production in a given period must be consumed, saved, or bequeathed, and hence:

$$y_t = \sum_{i=1}^{n} \theta_i c_{it(t)} + \sum_{i=1}^{n} \theta_i c_{it-1(t)} + \sum_{i=1}^{n} \theta_i B_{it-1(t)} + \sum_{i=1}^{n} \theta_i s_{it}$$

and hence:

$$k_{t+1} = \sum_{i=1}^{n} \theta_i s_{it}$$

[2.12]

By arbitrage, the return on savings and the return on capital are equal.

$$(1 + r_t) = \rho_t = \alpha\, k_t^{\alpha-1}$$

[2.13]

Politicians

Politicians in this model have no ideological preference, and simply desire to win the election.[2] Plurality maximizing politicians have no policy preference, and hence are identical. As such, clearly, if a unique dominant election-winning strategy exists, both candidates will choose it as their manifesto position. It is assumed that the rewards to power-sharing are sufficient to exceed the costs of nomination, i.e. even in the event of a certain tie, both candidates will compete.

It is assumed that as voters are setting strategy for periods of more than 25 years (one generation), within which more than one election might be expected in the real world, credibility is assumed. That is, no candidate can expect to deviate significantly from his or her manifesto position without losing support. As has been shown (e.g. by Enelow and Munger (1993) and Alesina (1988)), when either the game is repeated, or reputation effects are present, even ideologically motivated candidates may be able to credibly stand on manifesto positions which do not conform with their ideological bliss points.[3]

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[2] It may be seen (e.g. in Anderson and Glomm (1992)) that when candidates seek to maximize the *number* of votes cast in their favor, rather than the proportion of votes they receive, even ideologically indifferent candidates may choose not to converge. However, as has been shown by Cox (1990), even vote-maximizing politicians may converge when voters can cast multiple ballots.

[3] While the extension of this model to incorporate ideologically motivated politicians lies beyond the scope of the current paper, works by Alesina and Cukierman (1990), Wittman (1977, 1990) and others provide preliminary evidence of the patterns of candidate behavior which may be expected.

Political Structure

Voters take part in an election in each period, which determines the level of income taxation to be levied upon the young in that period, and hence the level of benefits to be received by the old in that period. All voters of all classes and ages present at time t may participate in the election at time t.

Agents decide upon a group- and age-specific optimal policy and then pick the candidate whose manifesto position most closely mirrors the outcome of the agent's ideal policy. Such optimal policy is shared by all members of that age and group, but individual agents are small relative to the size of the population, and cannot coordinate their voting. Voters weigh up the costs and benefits of participation, their level of interest, and the level of information they possess, and decide whether or not to vote.

Candidates, being motivated solely by the desire to win, will each carry out strategies which, given the opposing candidate's strategy, maximize their likelihood of winning.

Section III: The Agents' Decision

Economic Maximization Problem

Initially, the agent calculates his optimal level of bequests and saving, at any given tax rate. Then, by comparing the utility gained from the best response to all possible tax rates, the economically optimal rate of tax for agents of that type and age, given the behavior of other agents, may be determined (i.e. the rate of tax at which the optimal saving and bequest behavior yield the highest level of economic utility). The first stage in this process, is naturally to determine the optimal saving and bequest functions.

$$\underset{s_{it}, B_{it(t+1)}}{Max}\ U_{Eit}(Ln[c_{it(t)}] + \beta Ln[c_{it(t+1)}] + \delta Ln[B_{it(t+1)}]$$

s.t.

$$c_{it(t)} = w_{it}(1-\tau_t) - s_{it} + B_{it-1(t)}$$

$$c_{it(t+1)} = s_{it}(1+r_{t+1}) - B_{it(t+1)} + \varepsilon_{t+1}\ \mathrm{w}_{At+1}$$

[3.1]

These yield the following first order conditions:

(w.r.t. s_{it})

$$\frac{(1+r_{t+1})\beta}{s_{it}(1+r_{t+1}) - B_{it(t+1)} + \varepsilon\ \mathrm{w}_{At+1}} - \frac{1}{w_{it}(1-\tau_t) + B_{it-1(t)} - \mathrm{s}_{it}} = 0$$

[3.2]

(w.r.t. $B_{it(t+1)}$)

$$\frac{\delta}{B_{it(t+1)}} - \frac{\beta}{s_{it}(1+r_{t+1}) - B_{it(t+1)} + \varepsilon\ \mathrm{w}_{At+1}} = 0$$

[3.3]

Solving the latter yields:

$$B_{it(t+1)} = \frac{\left(\varepsilon w_{At+1} + s_{it}(1+r_{t+1})\right)\delta}{\beta+\delta}$$

[3.4]

Substituting this into the first first order condition and solving for s_{it} yields:

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$$s_{it} = \frac{(1+r_{t+1})(\beta+\delta)(w_{it}(1-\tau_t)+B_{it-1(t)})-\varepsilon\, \mathrm{w}_{At+1}}{(1+r_{t+1})(1+\beta+\delta)}$$

[3.5]

Once an agent has determined the optimal savings *behavior* of all agents, he can determine the future level of capital from the aggregate savings function, all of which is a function of the level of taxation.

Thus, the agent can measure how the level of taxation effect the capital stock, as formed by individuals' optimal savings decisions. In other words, an agent can construct: $k_{t+1}[\tau_t]$, and thus $U_{iE}[k_{t+1}]$, and hence $U_{iE}[\tau_t]$.

Naturally, once the election is concluded and the tax rate is revealed, all agents will operate along their predetermined optimal response path, found from the solution of their economic maximization problem.

From Eq.s 2.7, 2.9 and 3.5, and by substituting the solution for the dynamic bequest chosen by older agents, and the marginal products of capital and labor, the dynamic capital stock may be constructed:

$$k_{t+1} = \frac{\alpha\delta(\alpha+(1-\alpha)\tau_t)+(1-\alpha)\alpha(\beta+\delta)(1-\tau_t)}{\alpha(1+\beta+\delta)+(1-\alpha)E_1\tau_{t+1}} k_t^{\alpha}$$

[3.6]

From this determination of the capital stock, agents determine the level of future wages and interest rates, as well as the optimal behavior of both generations of current agents, in terms of savings, consumption and bequests. This, along with the steady state capital stock found below, allows the agent to determine the political utility functions of al agen

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all agents, and thus predict their behavior in an election, and hence the agent may form a rational expectation of the tax rate which will result from the election.

Social Maximization Problem

As well as the process of determining his economically optimal tax rate, the voter also constructs $U_{iS}[\tau_t]$, which represents the "social welfare" element of taxation. This element is based upon the agent's "long term" and (mildly) altruistic beliefs. This function is not maximized at the agent's short term optimal tax rate, but rather at the optimal rate for a member of his class in steady state.

This function is directly analogous to the steady state utility of a member of the voter's own group, measured over the range of possible tax rates, and is constructed from the solution to the steady state form of the agent's maximization problem:

$$\underset{s_i, B_i}{Max}\, U_{Si}(Ln[c_{iy}] + \beta Ln[c_{io}] + \delta Ln[B_i])$$

s.t.

$$c_{iy} = w_i(1-\tau) - s_i + B_i$$

$$c_{io} = s_i(1+r) - B_i + \varepsilon \, \mathrm{w}_A$$

[3.7]

As with the agent's dynamic behavior, the first order conditions of this maximization may be solved so as to yield the steady state savings decision of each member of each class. Again, by aggregation, this forms the steady state capital stock. Hence, the agent can construct $k_s[\tau]$, and thus, $U_{Si}[k_s]$, and hence $U_{Si}[\tau]$ where $k_s[\tau]$ is the steady state capital which would result from a stable tax rate of τ.

In the case of agent's role as social planner, it is apparent from the time invariant solution of the first order conditions Eq.s 3.4 and 3.5 that:

$$\mathrm{s}_i = \frac{(1+r)(w_i(1-\tau)+B_i)(\beta+\delta)-\varepsilon\,\mathrm{w}_A}{(1+r)(1+\beta+\delta)}$$

[3.8]

$$B_i = \frac{(s_i(1+r)+\varepsilon\,\mathrm{w}_A)\delta}{(\beta+\delta)}$$

[3.9]

And hence:

$$\mathrm{s}_i = \frac{w_i(1-\tau)(\beta+\delta)+\varepsilon\,\mathrm{w}_A\delta-\dfrac{\varepsilon\,\mathrm{w}_A}{(1+r)}}{(1+\beta+\delta)-\delta(1+r)}$$

[3.10]

From Eq. 2.7, 2.9, and 3.10, and by substituting the marginal productivities of capital and labor for the return on saving and the wage rate, the steady state capital stock may be written as:

$$\mathrm{k}_s = \left(\frac{\alpha(\delta+(1-\alpha)\beta(1-\tau))}{\alpha(\beta+\delta+(1-\tau))+\tau}\right)^{\frac{1}{1-\alpha}}$$

[3.11]

All agents now calculate their class's optimal level of savings, bequests and utility as a function of the model's parameters and the tax rate (see Appendix One). Thus, agents may determine the socially optimal tax rate for their group, based upon the rate which would maximize their utility in steady state, holding the behavior of other groups constant.

Participation and the Agent's Political Maximization Decision

Now in possession of the functions $U_{Eit}[\tau_t]$ and $U_{Sit}[\tau_t]$, representing the economic and social effects of taxation, the agent must decide whether or not to participate in the election, i.e. actually vote.

The agent's decision to vote is based upon three primary components. Firstly, the agent weighs the economic and social effects of taxation such that overall political utility may be measured by:

$$U_{Pit}[\tau_t] = \zeta\, U_{Eit}[\tau_t] + (1 - \zeta)\, U_{Sit}[\tau_t]$$

[3.12]

and hence the sensitivity of the agent to any candidate choice is reflected by:

$$\Delta U_{Pit}[\tau_{At}, \tau_{Bt}] = |U_{Pit}[\tau_{At}] - U_{Pit}[\tau_{Bt}]|$$

[3.13]

where $\Delta U_{Pit}[\tau_{At}, \tau_{Bt}]$ measures the weighted social and economic utility difference between the tax rates resulting from candidate A (with manifesto position τ_{At}) versus candidate B (with manifesto position τ_{Bt}) being elected.

The agent uses this function, derived from his economic and ideological utility, to determine an overall "ideal" tax policy, τ_{it}*[4]. Naturally, the voter then prefers the

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[4] Naturally, within each class, there will in fact be two bliss points, one for the old, and one for the young.

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candidate whose stated policy would, if elected, lead to the outcome closest to this optimum.

Secondly, the voter possesses an information cost function, $I_{Pit}[\tau_t, \tau_{it}^*]$, which describes the voters' *non-economic*[5] cost of obtaining sufficient information to participate. In turn, this reflects the level of "free" information available to the agent. As has been shown from Downs (1957) on through to Popkin (1993)[6], voters in elections in which their mass is trivial relative to the population as a whole, do not have an incentive to gain information concerning the nature and impact of political alternatives. As such, their social conditioning generally leads to lower information costs, and hence a higher level of informedness, for policy alternatives which are close to the agents' (or the groups') bliss points.[7]

$I_{Pit}[\tau_{At}, \tau_{Bt}, \tau_{it}^*]$ is minimized at $\tau_{At} = \tau_{Bt} = \tau_{it}^*$, and increases as either candidate moves away from that position. I assume that:

$$I_{Pit}[\tau_{At}, \tau_{Bt}, \tau_{it}^*] = \mu\left(|\tau_{At} - \tau_{it}^*| + |\tau_{Bt} - \tau_{it}^*|\right) \quad [3.14]$$

Clearly, if $\mu=0$ there is no information cost problem, and agents are fully informed under all circumstances, and as μ increases, agents are increasingly narrowly

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5 These costs are not considered as part of the agents' consumption decision. Relative to the economic costs and benefits involved, they are extremely small. They remain significant, however, as although they are very small relative to the economic and social motivations, the agent has very little impact on the political outcome, although *it* has significant impact on *the voter*. Thus, when the agent considers the effect of the election on himself, *and* his effect on it, the overall effectiveness of his vote is sufficiently small that information costs are a non-trivial determinant in the decision to participate.

6 This aspects of Downs' work has received significantly less attention than the predictions concerning minimum differentiation and the paradox of participation.

7 Lupia (1992) investigates the role of incumbents ability to manipulate the supply of low cost information to "busy" voters, thus deliberately alienating the supporters of their potential opponents.

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informed about the election (i.e. increasingly uninformed about choices which lie distant from their bliss point).

Thirdly, there are explicit costs to participation, γ_{ij} for member j of group i. These costs are uniformly distributed among agents of each class, and the distribution of costs for each class and age group is the same, such that $Min[\gamma_i] < 0$, $Max[\gamma_i] > 0$, $E[\gamma_i] > 0$. As such, some agents (those facing negative overall costs) will always participate (even in the absence of political motivation concerning the candidate choice), but most agents will only participate if explicit- and information-costs are low, or the agent is highly sensitive to the policy outcome.

Thus the participation decision for agent j of type i may be seen as:

$$\underset{P_{ij}}{Max} \left\{P_{ij}\left(\Delta U_{Pit}[\tau_{At}, \tau_{Bt}] - I_{it}[\tau_{At}, \tau_{Bt}, \tau^{*}_{it}] - \gamma_{ij}\right)\right\} \text{ s.t. } P_{ij} \in \{0,1\}$$

[3.15]

hence in order to maximize utility from participation:

$$P_{ij} = 1 \text{ if } \left(\Delta U_{Pit}[\tau_{At}, \tau_{Bt}] - I_{it}[\tau_{At}, \tau_{Bt}, \tau^{*}_{it}]\right) > \gamma_{ij}$$
$$P_{ij} = 0 \text{ otherwise}$$

[3.16]

For an individual agent, participation is thus discrete between 0 and 1, however the distribution of γ_{ij} is such that participation is a continuous variable within each group, and that under all circumstances *some* agents will vote. However, the relative level of participation between different agent types and age groups is determined by the agents' bliss points and the positions of the candidates.

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Section IV: Equilibrium

A rational expectations Nash equilibrium for this model is a sequence of taxes $\{\tau_t\}$, a sequence of prices $\{w_{it}, r_t, \rho_t\}$, a sequence of allocations $\{c_{it[t]}, c_{it[t+1]}, k_t\}$ and a sequence of agent participation levels $\{P_{ij}(\tau_i^*, \tau_t)\}$ such that at these taxes, prices, allocations and participation levels, each candidate chooses a strategy which maximizes that candidate's utility, agents' utility is maximized, firms maximize profits, all markets clear and the government's budget constraint is satisfied.

Section V: Agents' Combined Political Bliss Points

It is worthwhile at this stage to consider the nature of the agents' bliss points. The distribution of the bliss points themselves is a powerful indicator of the forces generating the equilibrium of the plurality maximizing electoral game.

As has been mentioned, the economic and social utility functions of agents from a heterogeneous population depend on taxation in a non-linear manner. As such, it is not possible to algebraically solve the overall political utility function $U_{Pit}[\tau_t]$ for τ_t, so as to find the agent's bliss point (the tax rate which maximizes lifetime $U_{Pit}[\tau_t]$).

Simulations to determine the nature of $U_{Pit}[\tau_t]$ and τ_i^* may be sensitive to the choice of initial conditions. Thus, repeated simulations were undertaken with different initial tax rates (and thus different initial capital stocks). These simulations were performed iteratively until a stable form for $U_{Pit}[\tau_t]$ and τ_i^* were found. Furthermore, it was found that the system converged to these stable forms very quickly, and that the nature of $U_{Pit}[\tau_t]$ and τ_i^* was almost entirely independent of the initial conditions. From these political utility functions and tax bliss points, it was possible (as is described at the start of Section VI) to determine the outcome of the electoral game, i.e. the equilibrium tax rate. This tax rate was then imposed as the initial tax rate, and thus as the determinant of the initial capital stock. The simulations were then re-run to ensure that future elections continued to result in this equilibrium tax rate.

Thus, for any parameter set, $U_{Pit}[\tau_t]$, and hence τ_i^* may be generated numerically. From Eq.s 3.6 and 3.11, agents determine the dynamic and steady state demand for capital within the population as a whole. As a result, each agent determines the effect of taxation on capital, and hence on wages, interest rates, savings, bequests and utility.

In other words, $U_{Pit}[\tau_t]$ shows how the agent's political utility is affected by changes in the tax rate, to which all agents respond through utility maximization, as described earlier. Although the dynamic and steady state capital stocks can be solved analytically, the economic and social utility functions which comprise $U_{Pit}[\tau_t]$ are highly non-linear in τ_t, and as such must be dealt with through numerical simulation.

From the first order conditions of the agents' maximization problem, it is possible to determine each agent's optimal (steady state and dynamic) savings, bequests and consumption as a function of taxation. The agent thus possesses the components of $U_{Pit}[\tau_t]$.

From $U_{Pit}[\tau_t]$ it is possible to determine τ^*_{iy}, and τ^*_{io}, the tax rates which maximize lifetime $U_{Pit}[\tau_t]$ for young and old agents respectively. In order to determine τ^*_{iy}, and τ^*_{io}, the numerical solution of $\frac{\partial U_{Pit}[\tau_t]}{\partial \tau_t} = 0$ must be found. For agents whose bliss points lie at the corners of the tax policy space, a sufficient condition for a 0% tax bliss point is that

$\frac{\partial U_{Pit}[\tau_t]}{\partial \tau_t} < 0 \quad (0 \le \tau_t \le 1)$ and likewise for a 100% bliss point $\frac{\partial U_{Pit}[\tau_t]}{\partial \tau_t} > 0 \quad (0 \le \tau_t \le 1)$.

The parameter values used in these simulations are described in Table 1.

Proposition 1: Within any productive class, the bliss point of the old will be for a level of social security taxation greater than or equal to that of the young. Furthermore, within any age group, the bliss point of wealthier agents will be for a level of taxation less than or equal to the bliss point of poorer agents.

By assumption, within any productivity group, agents of differing ages will share their social bliss point, as it derives from the *steady state* welfare of their class. However, the economic well-being of each agent is age specific. Under all simulations tested, old agents uniformly benefit from higher taxation. As taxes rise, they are able to consume more in old age, and bequeath more to their children. As such, in equilibrium, all old agents economically prefer a 100% tax rate.

For the young, however, the effects of taxation are almost universally detrimental to economic utility. Although young agents receive an increased bequest from their parents, their loss of wage income (through taxation) exceeds the increased bequest (except for the very poorest young agents, whose incomes are very small, and hence who are highly sensitive to the size of the bequest that they receive). As such, in equilibrium, all but the poorest young agents economically prefer a zero tax rate.

Table 1 **Parameter estimates used in baseline and robustness testing of simulations.**

Parameter:	*Meaning:*	Baseline value(s)	Range of values tested:	Comments:
α	Capital's share of production	$\alpha = 0.3$	$0.2 < \alpha < 0.4$	$\alpha = .3$ is the most commonly accepted numerical estimate of capital's share of production.
β	The discount rate for second-period consumption	$\beta = 0.5$	$.10 < \beta < .95$	$\beta = .50$ over a 25 year generation is equivalent to approximately a 3% p.a. discount rate.
δ	The discount rate for the bequest motive	$\delta = 0.5$ or $\delta = 0.25$	$.0.5 < \delta < .95$	It seemed reasonable to accept that δ should be no larger than β, but still non-trivial. Full baseline simulations were run (with entirely equivalent results) for $\delta = 0.5$ and $\delta = 0.25$
ζ	The relative weighting of the economic to the social outcomes.	$\zeta = 0.5$	$0 < \zeta < 1.0$	ζ was set at 50% as a baseline, so weighting neither the economic nor the social characteristics more strongly.
n	The number of income groups in society.	$n = 7$	$1 \leq n \leq 19$	The baseline grouping of society into 7 productvity classes mirrors the standard 7-point "class" scale used in empirical political science studies. There is, however, no particular significance (in design or implementation) to this value.
h_i	Agent productivity (as a percentage of mean agent productivity).	N/A	$0.05 \leq h_i \leq 4.0$	While naturally, within any given simulation, the average of h_i must equal 1.0, there exists a wide range of possible productivities to be assigned to non-average agents.
μ	Information costs.	$\mu = 0.25$	$0.0 \leq \mu \leq 4.0$	As μ increases, the rate at which information costs increase rises, and hence agents are increasingly likely to find that the disutility of voting for a low-quality preferred candidate is sufficient to justify non-participation.
τ_x	(Shocks to) the "historical" level of taxation.	N/A	$0\% \leq \tau_x \leq 100\%$	Under normal circumstances, τ_x, $E_{t-1}[\tau_t]$ and $E_t[\tau_{t+1}]$ are endogenously determined within the model. However, as part of the simulation robustness testing, they were allowed
$E_{t-1}[\tau_t]$	(Shocks to) the previous expectation of present taxation.	N/A	$0\% \leq E_{t-1}[\tau_t] \leq 100$	to be shocked from their equilibrium values. The model transpired to return to equilibrium very rapidly, and was not highly susceptible to such shocks.
$E_t[\tau_{t+1}]$	(Shocks to) the present expectation of future taxation.	N/A	$0\% \leq E_t[\tau_{t-1}] \leq 100$	

Given these polarized economic bliss points, but the intrinsically shared socially optimal tax rate, it is clear that:

$$\tau^*_{iy} \leq \tau^*_{io} \qquad \text{given } h_i$$

[5.1]

where τ^*_{iy} is the bliss point of a young agent of type i and τ^*_{io} is the bliss point of an old agent of the same type.

Furthermore, within each age group, the tax rate that maximizes overall political utility is dependent on the agent's productivity. This result is derived from the agent's social utility function, as all old agents and almost all young agents economically desire 100% or zero tax rates respectively.

Most agents do not, in steady state, desire corner solutions to the tax problem. As taxes rise, agents receive larger social security payments in old age, and also receive larger bequests when young. Naturally, this also means that they are able to *give* larger bequests when old. Countering this effect, however, as the tax rate rises, it can be seen from Eq. 3.11 that capital, and hence output and wages will fall. Thus, even agents who benefit from the transfer system are effectively receiving a larger slice of a smaller pie, and as such they will eventually be made worse off by excessive taxation.

However, these effects are not even across the population, as the social security system also does transfer income from the wealthy to the poor. As such, in steady state, although most agents will prefer some interior tax rate, the rate which is optimal depends inversely on the agent's productivity. Poorer agents benefit from increased bequests and a larger social security payment, (as well as from increased interest rates) while taxes diminish the level of pre-and post-tax wages.

Wealthier agents likewise benefit from increased bequests and social security payments, as well as higher interest rates, over some tax range, but these benefits will increasingly be overwhelmed by the increased tax burden which the agent faces, i.e. the agent loses too much wage income to maintain savings, and hence bequests, consumption and utility.

Thus:

$$\frac{\partial \tau^{*}_{iy}}{\partial h_i} \leq 0, \ \frac{\partial \tau^{*}_{io}}{\partial h_i} \leq 0$$

[5.2]

The inequalities described in proposition 1 and Eq.s 5.1 and 5.2 become strict if, of n classes of agent, and hence 2n separate bliss points, there are (2n - 1) bliss points for positive taxation and (2n - 1) for less than 100% taxation. Distributions of bliss points which conform to this pattern are described hereafter as *weakly interior.*

Proposition 2: Given a distribution of agents, as agent productivity increases, the difference between agent bliss points within each age group diminishes.

Again, clearly, the distribution of agent bliss points is derived from the agents' socially optimal level of tax. While it is not possible to algebraically solve for the form of τ^{*}_{is}, it may be determined numerically (for further details, see Appendix 2). From numerical calculations across a wide range of parameter values, the following pattern is uniformly observed:

$$\frac{\partial^2 \tau^*_{iso}}{\partial h_i^2} \geq 0 \quad , \quad \frac{\partial^2 \tau^*_{isy}}{\partial h_i^2} \geq 0$$

[5.3]

and hence from Eq.s 3.12 and 5.3:

$$\frac{\partial^2 \tau^*_{io}}{\partial h_i^2} \geq 0 \quad , \quad \frac{\partial^2 \tau^*_{iy}}{\partial h_i^2} \geq 0$$

[5.4]

Thus, the distribution of the agents' overall tax bliss points is a convex function of the agents' productivities. This behavior appears to be based upon the decreasing nature of marginal utility. Given the form of the agents' utility functions, agents who are poor have (at any tax rate less than 100%) a lower absolute level of utility than rich agents, but a higher level of marginal utility from consumption and bequests. It may be shown that in steady state, the change in utility caused by a given change in the tax rate is greater for poor agents than for wealthy ones. As such, given the existence of some optimal tax rate for each class of agent, the difference between the bliss points of two wealthy agents will be less than the difference between the bliss points of two otherwise comparable poor agents, as the marginal impact of sub-optimal tax rates is far greater on low productivity agents than it is on the wealthy.

Section VI: Results of the Plurality Maximizing Electoral Game

Once the agents' bliss points have been determined, in order to locate the equilibrium, it is necessary to find the set of tax manifesto positions which, given the

agents' distribution, and hence the distribution of $U_{Pit}[\tau_t]$ functions, that will maximize the *candidates'* utility.

For any combination of strategies, τ_A and τ_B, each voter must decide on a preferred candidate (unless the agent is absolutely indifferent between the candidates (an eventuality which is effectively limited to the case $\tau_A = \tau_B$)), and then each agent must decide, given the choice of candidates on offer, whether or not to participate.

To do this, $U_{Pit}[\tau_A]$ and $U_{Pit}[\tau_B]$ must first be calculated. Which of these is greater determines whether A or B is the preferred candidate. Given this choice of the more-desired candidate, the agent's likelihood of participation must be determined, from Eq. 3.16.

This process must be repeated for the representative agent of each type and age group within the population. As each of these candidate choices and participation levels is dependent upon τ_A and τ_B, each must be recalculated for every combination of possible candidate strategies. In the case of the simulations used in this paper this demanded the determination of P_{ij} for each age and productivity combination for up to 10,000 strategy combinations.

Thus, the vote cast for candidate A by members of generation x of type i, given candidate positions τ_A and τ_B is:

$$\begin{aligned} V_{ixA}\left[\tau_A, \tau_B\right] &= \theta_i \overline{P}_i \quad \text{if and only if } \tau_A \text{ is preferred to } \tau_B \\ &= 0 \quad \text{otherwise} \end{aligned}$$

[6.1]

where $\overline{P}_i$ is the numerical average of P_{ij} within that age and productivity group. As such, the total number of votes cast for candidate A is:

$$V_A[\tau_A, \tau_B] = \sum_{i=1}^{n} \sum_{x=t-1}^{t} V_{ixA}[\tau_A, \tau_B]$$

[6.2]

By comparing $V_A[\tau_A, \tau_B]$ and the corresponding vote total for candidate B, $V_B[\tau_A, \tau_B]$, the electoral winner may be found, based upon the strategy combination $\{\tau_A, \tau_B\}$. It is thus possible to determine the electoral outcome (in terms of the victor and hence the "winning" tax rate) from any combination of strategies.

This process generates a winner, and an outcome tax rate from any strategy combination $\{\tau_A, \tau_B\}$. Essentially, this is the direct analog of the normal form of the strategy game the candidates play, as their payoff functions are zero-sum. Thus, any strategy combination yields a single payoff, positive for the winner, negative for the loser, and zero in the event of a tie. From this payoff matrix, it is possible to locate any Nash equilibria strategy sets.

In this model, without exception, the equilibrium found by simulation was not only a unique Nash equilibrium, but a Nash equilibrium formed from symmetric dominant strategies for the two candidates. That is, for each candidate there exists a unique strategy that yields victory *irrespective*[8] of the opposing candidate's strategy, unless the opponent employs an identical strategy, in which case a tie results.

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[8] Hence a more restrictive form of solution than a general Nash equilibrium, in which the candidate's strategy is optimal *given* the opposing candidate's strategy.

However, there may also exist, alongside the dominant strategy, one or more strategies which, within a different, more restricted, policy space, would be dominant. Note, this is not merely to say that when the strategy space is restricted such as to remove the initially dominant strategy, the equilibrium tax rate will be held by a binding constraint to the edge of the strategy space closest to that strategy. Instead, within such a restricted policy space, there may exist a dominant strategy in the *interior*.

Consider an election wherein there are only two blocks of voters, a larger group which has a bliss point for high taxes, and a smaller group for low taxes. Both groups' preferences are such that they become alienated rapidly as the candidates move away from their respective bliss points. Clearly, if they become sufficiently alienated sufficiently quickly, then candidates may effectively choose between pleasing one group and pleasing the other. All things being equal, the candidates choose to please the larger group, and the smaller group is alienated, and fails to participate.

However, if the strategy space is restricted to low-to-medium tax rates alone, then there exists some strategy space such that the level of alienation among the supporters of the high-tax platform will overcome their numerical superiority, and the less numerous group is decisive across the entire restricted strategy space, and hence the dominant strategy will be that preferred by the low-tax group. Strategies with the potential to dominate within restricted spaces prove common in this model, as long as information costs, and hence the disutility of voting for a poor quality candidate, are non-trivial. For further discussion of such strategies, see Appendix Three.

Nonetheless, a dominant strategy *is* found to exist under all parameter specifications, policy spaces and simulations tested, and that strategy defines the equilibrium outcome of the electoral game. Likewise, although strategies which could dominate restricted policy spaces are common, they do not exist within *all* strategy sub-spaces. As such, for many sub-spaces which eliminate the initial dominant strategy, the new dominant strategy within the restricted space will be a binding constraint against the limit closest to the previous dominant strategy.

The existence of strategies which could dominate restricted policy spaces merely implies the existence of *some* restricted policy space *within* which that strategy would yield the equilibrium of the game.

It may be seen that if there exists a single dominant strategy, across either the global policy space or some local subspace, then both plurality maximizing candidates will converge to that point. In that case, voters can perceive no difference between the candidates, and thus only those agents with negative overall costs participate.

This is not, however, to say that candidate placement and voter participation are irrelevant in this case. Instead, the voters' participation decision is what constrains the candidates to this equilibrium, i.e. how likely the voters would be to participate, if either candidate moved marginally away from the equilibrium.

INDIVIDUAL CHARACTERISTIC EFFECTS

Proposition 3: Given a weakly interior distribution of agents' bliss points (as defined in the discussion of proposition 1), and non-trivial information costs, agents who are poorer than those whose ideal policy is reflected in the equilibrium outcome are less likely to participate than voters who are wealthier.

Thus, if one constructs the voter whose ideal policy would have been for the actual outcome, and define that agent's productivity as $\hat{h}_i$, it is true that, within either age group, if the distribution of bliss points is weakly interior:

$$P_i[\tilde{h}_i < \hat{h}_i] < P_i[\tilde{h}_i > \hat{h}_i], \text{given} \left|\tilde{h}_i - \hat{h}_i\right|$$

[6.3]

where $\tilde{h}_i$ is any h_i such that $\tilde{h}_i \neq \hat{h}_i$.

This does not necessarily imply that $\frac{\partial P_i}{\partial h_i} > 0$ for all agents. Participation is still dependent on the agent's satisfaction with the available candidate choice, as well as on the agent's social and economic sensitivity to tax. If the distribution of voters is such that almost all voters are extremely poor (and hence offset by a handful of "super-rich"), then the wishes of the poor will dominate, and the result will be that the rich will fail to participate. However, it does imply, clearly, that the wealthy, in general "punch above their weight", i.e. they have a disproportionately large impact on the outcome of the electoral game.

This result derives from the distribution of bliss points, as described in Section V. Agents who are wealthier than the mean generally have far less diverse bliss points than those who are poorer than the mean. Thus, a policy which is ideal for one wealthy group will also be close to ideal for other wealthy groups, and hence the majority of wealthy agents will have a high probability of participating in favor of that policy.

In contrast, a policy which is ideal for one poor group will also be distant from the bliss points of other poor groups, so the majority of low productivity agents will have a low probability of participating in favor of that policy.

If the distribution of agents and the parameter specification leads to a distribution of bliss points which is *not* weakly interior, or if information costs are trivial, then the relative participation rate between wealthy and less-wealthy agents is parameter specific, although under all simulations tested, Proposition 3 still holds for those agents whose bliss points are weakly interior.

Proposition 4: Given a weakly interior distribution of agents' bliss points, the average level of participation among old agents is greater than the average among young agents.

Hence, under all simulations:

$$\overline{P}_{io} > \overline{P}_{iy}$$

[6.4]

Young voters, although always economically opposed to high taxation, do find the loss of initial take-home wages *somewhat* offset by higher bequest receipts, the interest rate effects of higher taxes, and the increased bequests which they receive from their parents. The economic utility of the old, however, is unambiguously improved by increasing taxes. Thus, the economic component of political utility is somewhat more tax-sensitive for the old wealthy than for the young wealthy, and as such, given candidates at any given distance from the agent's bliss point to the policy outcome, the young will tend to be less likely to participate than the old.

From the propositions 3 and 4, it may be seen that a convergent outcome of the game reflects the desires of the old over those of the young, and of the wealthy over those of the poor. Under virtually all simulation run[9], this leads to an equilibrium tax rate which is lower than that of the median agent's bliss point, as long as the divisions within society are primarily driven by income, not age.

Proposition 5: As agents become increasingly concerned with the economic impact of the election's outcome, and hence less sensitive to the social outcome, society ceases to be polarized by wealth, and is increasingly delineated by age. As such, taxes increase, and the capital stock, wages and output decrease, while interest rates rise.

As agents are increasingly focused on the economic effects of taxation, agents' bliss points diverge rapidly away from the median. Young agents will increasingly prefer a zero rate of taxation, and old agents will rapidly find the revenue maximizing rate optimal. This has two principal effects. Firstly, as ζ (the weighting of economic to social motivations in $U_{Pit}[\tau_t]$) increases, and agents' bliss points polarize, candidates located near to any dominant strategy will be increasingly unacceptable to agents from the age

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9 With the exclusion only of those in which the population distribution was asymmetric and the costs of participation were very high, such that a single class and age group was likely to dominate the election. Naturally, in this case, the bliss point of the dominant group was the sole determinant of the outcome.

group whose bliss point lies further from the dominant strategy. As such, one age group or the other will tend to be almost completely alienated.

Conversely, as ζ falls, agents are increasingly willing to accept a centrist policy, and as such it becomes more likely that (at any parameter specification and voter distribution) agents will converge to some common centrist policy. As when ζ is low, the majority of agents have *similar* bliss points, the distance from any agent's bliss point to that of any other agent is small, and as such the costs of participation, and hence the level of alienation are low. Thus, given the parameter specification and population distribution, as ζ falls, the threshold value of μ beneath which centrist convergence is possible rises, and hence even under significant information costs and thus high levels of proximity sensitivity, the likelihood of alienation will be low.

Secondly, as ζ rises, the bliss point of the old will tend to become more important, and taxation will thus rise. This follows from proposition 4. Because the old are more sensitive to tax in economic utility terms (as their economic utility responds unambiguously to increased benefits), if the election is a straight competition between the young and the old and costs are symmetric, the old will be more likely to participate and hence dominate the election.

Population Distribution Effects

There are three key components to the population distribution. Firstly, there is the range over which the population is spread (i.e. the minimum and maximum of h_i). Secondly, there is the allocation of agents within that range, which may be broadly characterized as one of four types. Homogeneous distributions[10] encompass the perfectly homogeneous (wherein h_i=1.0 for all agents) and low-variance normal distributions. Uniform distributions contain equal numbers agents from each productivity group. Bimodal distributions have relatively few agents in either tail, or at the median, but two "power blocks" located to the left and right of the median. Log normal distributions are asymmetric with a relatively large proportion of the population located below, but close to the mean, and a long tail above the mean. Thirdly, the number of classes over which the agents are located is a significant factor in the nature of the equilibrium. Clearly, the more groups, the smaller the classes and the less effective political mass each class of agent possesses.

Proposition 6: As the limits of the population distribution expand towards the limits of weakly interior bliss points, equilibrium taxes will remain steady or fall. If the range expands sufficiently that a large proportion of the population has bliss points at 100% or 0% taxation, then the effect on equilibrium taxation is ambiguous.

The narrower the range over which the agents are distributed, the fewer the agents who possess bliss points for corner solutions. As such, naturally, this will tend to

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[10] Clearly, within this model, a perfectly "homogeneous society" is something of a misnomer. Indeed, the homogeneous society is the most polarized of all. Given parameter values, a society comprised solely of one class of agent splits evenly into two groups; the old, for whom $\tau^{*}_{iPo} \geq \tau^{*}_{iS}$, and the young, for whom $\tau^{*}_{iPy} \leq \tau^{*}_{iS}$. There are no other groups with more extreme preferences, nor any with compromise positions. Obviously, the two age groups are equal in size, and in general their preferences are approximately equally sensitive to taxation choices away from their bliss points.

reinforce the likelihood of centrist convergence, as a greater number of agents will have broadly similar bliss points. Furthermore, when the range is sufficiently small (i.e. there are sufficiently few extremely poor or rich agents), the comparative similarity of wealthy agents' bliss points as compared with those of the poor ensures that the wealthy agents' wishes will, in general, be over-represented in the outcome.[11]

As the range over which the agents are distributed increases, and the distribution of bliss points ceases to be weakly interior, more agents will possess a bliss point for either 100% taxation (in the case of the very poor) or 0% taxation (the very wealthy). Whether this will lead to a higher or lower tax rate in equilibrium is largely parameter dependent, and as such, the effect of increased population range on taxation is ambiguous.[12]

Given the range of agent productivities in the economy, the allocation of those agents also has a great impact on nature of the outcome of the game. However, as described above, the effects of changes in the distribution are ambiguous where the range of the agent distribution generates a large number of voters with corner solutions for bliss points.

Proposition 7: Relative to the equilibrium outcome of an election with uniformly distributed agents with weakly interior bliss points, highly homogeneous distributions have an ambiguous effect on the outcome, while bimodal

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[11] The restricted range require for weakly interior bliss points within this model is in general relatively small. This results from the overly generous form of social security transfer system. If there was a significant correlation between the agent's *own* productivity and the benefits received, or if there was a cap on the income against which taxes could be drawn, then a wider range of agents would possess interior tax bliss points.

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distributions lead to higher taxation in the great majority of simulations[13]*, and log-normal distributions lead to higher taxation under all circumstances simulated.*

When the distribution of agents is highly homogeneous, there is little differentiation between the vast majority of agents in terms of class, but a great deal between age groups. As such, the findings of propositions 6 and 7 lead us to expect, and find, that taxes will be higher than in the case of a uniform distribution.

Bimodal distributions also lead to higher levels of taxation, and the stronger the two modes are, the more reinforced this effect is. Essentially, as two strong modes appear (one for high tax and one for low tax), the bliss point similarity advantage which wealthy agents possessed disappears. Once a large proportion of the poor are closely congregated, as are the bulk of the wealthy, the relative similarity of all wealthy agents' bliss points ceases to confer significant advantages to them.

This effect is carried further in the presence of a log-normal population distribution. Under a log-normal distribution the vast majority of poor agents have similar bliss points, whereas the rich are now less populace and have a more distended set of bliss points. As such, their bliss points are no longer mutually supportive, and hence wealthy agents' disproportionate ability to draw down the tax rate is diminished.

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[12] See Appendix 2 for demonstrations of the behavior of agent bliss points under different parameter specifications.

[13] The only exceptions being the case of a very restricted number of classes (e.g. n=3) or very high costs to participation, such that no group would lend significant support to a candidate located at any other group's bliss point.

Proposition 8: Increasing the number of classes within a given distribution has a small and ambiguous effect on equilibrium taxation, but makes centrist tax rates more likely, and hence the level of alienation lower. Furthermore, it reduces the likelihood of the existence of strategies which are dominant in interior of restricted policy spaces and it implies that any such strategies which do exist will dominate only within a smaller (more localized) policy space.

As the number of classes increases, each class becomes smaller, and any one class is thus less likely to be able to dominate the election. However, as the agents who are removed to form the intermediate classes are spread approximately evenly between a slightly higher class and a slightly lower one, the net effect on "average" bliss points is negligible and ambiguous.

However, as each local group becomes weaker, it is less likely that an extreme solution will result from the election. As powerblocks fade, centrism rises. Clearly, this will lead to lower levels of alienation, and hence higher overall participation rates.

Equally significantly, it will reduce the number of strategies which could dominate within the interior of restricted policy spaces. Such strategies rely upon the existence of a large group of agents with very similar bliss points, but who will largely be alienated by the initial dominant strategy. As such groups are disbanded, and the population is instead formed into a continuum of voters, groups of similar agents no longer share common goals, and hence their ability to appeal as a block fails. In other words, classes have far greater power through what amounts to a collective political platform than individual agents can have.

However, it should be noted that, dependent on the parameter specification and the distribution of agents, strategies which dominate the interior of restricted policy spaces persist under certain circumstances, particularly when information costs are high (and hence so is alienation) or where the agents are distributed uniformly or bimodally.

Section VII: Conclusions and Extensions of the Model

Before summarizing the results of this paper, it is important to remember that they are driven by nothing more than the intrinsic differentiation of the agents, by age and by productivity. Their personal parameters, distribution and preferences are in all other ways identical. It is quite possible to generate all manner of interesting electoral results if agents may be distributed unevenly or given different behavioral patterns, but that is not the case here. Furthermore, their preferred policy and their participation behavior, and hence the equilibrium outcome of the election, is derived from utility maximization, rather than by arbitrary assumption.

The model's principal conclusions are fivefold. Firstly, when significant numbers of voters are alienated, pure centrist convergence, with a unique dominant strategy which persists (either as the active strategy or from a binding constraint) across all policy spaces, is rare. This is the case almost by definition. Alienation implies the existence of abstaining voters who *would* have voted had they been presented with a better candidate. Likewise, some of the voters whose votes ensure victory for the dominant strategy would be less likely to participate if such a strategy was not on offer. As such, the role of the institutional *construction* of the policy space is critical.

It is by no means obvious that the policy space for an issue such as social security taxation need necessarily be from 0% to 100%. If the population structure changes, the dominant equilibrium should change with them and this may alienate voters who were pleased with the previous outcome, but not with the new one. If those voters were the "powerbrokers" of the previous equilibrium, and are permitted to specify the policy space for the new election, they may be able to restrict the space to one such that their own bliss points *again* represent the dominant outcome.

This implies nothing so blatant as restricting the tax level to a constraint against which the tax rate will be binding, but instead, by specifying a sufficiently limited range, they may alienate the vast majority of their opponents so effectively that the dominant solution is within the interior of the restricted policy space. However, such a role in determining the policy space would clearly change the nature of the electoral game, and as such lies beyond the scope of this paper, although some inferences may be drawn from the "agenda setting" literature of committee-based, such as Rosenthal (1990), and models of information-restriction, e.g. Lupia (1992).

Secondly, within the population as a whole, the old and the wealthy will tend to have higher participation rates, all things considered, than the poor and the young. This result, clearly coincides with conventional political wisdom. This result is derived from the fact that the old are more single-minded in their response to changes in taxation (and hence benefits) and that the wealthy form a more mutually supportive front in favor of lower taxes, and as such, are able to disproportionately affect the equilibrium.

Thirdly, as agents become more proximity sensitive, the wealthy will tend to benefit, i.e. when society becomes polarized, the wealthy form a more coherent force than the poor, and are, as such, able to dominate the outcome, even when they represent an absolute minority of the population.

Fourth, as the population becomes more socially concerned, and less motivated by the economic outcome, the political debate will generally be broadly centrist, and based upon class. If agents are predominantly motivated by economic considerations, then the debate will tend to polarize, and be characterized by age differences.

It is also worthwhile at this stage, to consider the implications of a less rigid class structure. Given that voters in this model live for only two periods, it seems reasonable that they should be fully aware of their *own* class, but not necessarily that of their offspring. If agents are unsure of the class of their offspring, they should include more than one class's welfare in their social utility calculations. In the extreme case, where agents are randomly distributed among n classes, the social utility function would be identical for all agents. This would certainly tend to lead to greater centrism, and a lower level of alienation, although it would not necessarily ensure the existence of just two bliss points (one for the old, one for the young), as there would also exist n^2 combinations of old and young within a given period, and hence there would be young poor agents whose parents would be sufficiently wealthy to *not* give a large enough bequest to offset taxes. Overall, however, as agents become concerned with more than their own welfare and that of their specific class, they are more likely to share *some* common elements in the determination of their bliss points, and as such will tend to have less dissimilar bliss points, leading to a higher level of centrism and lower levels of alienation.

Lastly, as society becomes less unequal, and hence the income range over which the vast majority of agents is spread diminishes, then the result will tend to reflect both centrism and the wishes of those with as sub-median bliss point for tax. If society becomes unequal and highly polarized, only then *may* the poor be able form a sufficiently large voting block to dominate the election, at which point the equilibrium could shift violently in their favor. Thus, a more even society, with relatively few poor agents will tend to be stable and will tend to prefer a low rate of taxation, as we would expect.

The results of this model open further possibilities. It is apparent that under a shifting social structure, control of the policy space may lead to minority rule, if the policy space for the next election may be determined by the winners of the present vote. Likewise, the entry of third candidates may lead to candidate differentiation, and hence non-convergence. To this point it has been specified that there are only two potential candidates in any election. As such, when a single dominant policy position exists, they will converge to it. If, however, there exists the possibility of the entry of a third candidate, then the position becomes far less obvious.

As has been shown by Osborne (1993), Gutowski and Georges (1993) and other authors, the strategic behavior of politicians facing potential entrants is likely to be very different to that of candidates operating in a closed system. Indeed, Chressanthis and Shaffer (1993) have found evidence that alienation has been a significant factor in the threat of potential entrants in recent U.S. presidential elections. Furthermore, Hug (1995) has demonstrated the possibility of the presence of third parties in the equilibria of spatial games wherein voters are not fully informed about the candidates' preferences, as is particularly likely where candidates have ideological and plurality-seeking motivations.

While third-candidate entry lies beyond this paper's scope, and would add a further dimension to the model's complexity, preliminary simulations indicate that if entry is possible, many of the dominant strategies found in the current model may be indefensible against the entrant, in particular when there are dominant strategies across different policy spaces.

Clearly, there is a role for an expansion of this model to incorporate these changes, as well as introducing ideological motivations for the candidates, under which circumstances the equilibrium outcome is by no means necessarily convergent.

Appendix 1

The nature of steady state savings and bequests

From the solution of the derivative of steady state savings with respect to taxation, it is possible to specify the conditions under which savings will rise in taxes, in the form of a lower limit on productivity, h_i^+. h_i^+ represents the a productivity level *so low* that, under prevailing tax rates, savings rise in taxation:

This path clearly depends solely on α, β, δ and τ. Plotting h_i^+ against τ for combinations of β and δ ranging from .1 to .75 (assuming α = .3), it is apparent that the path of h_i^+ is not dramatically affected by changes in β and δ, and hence that for any reasonable parameter set, at low tax levels all agents' savings decrease in taxation, and even at high tax rates only low productivity agents may have savings which rise in taxes.

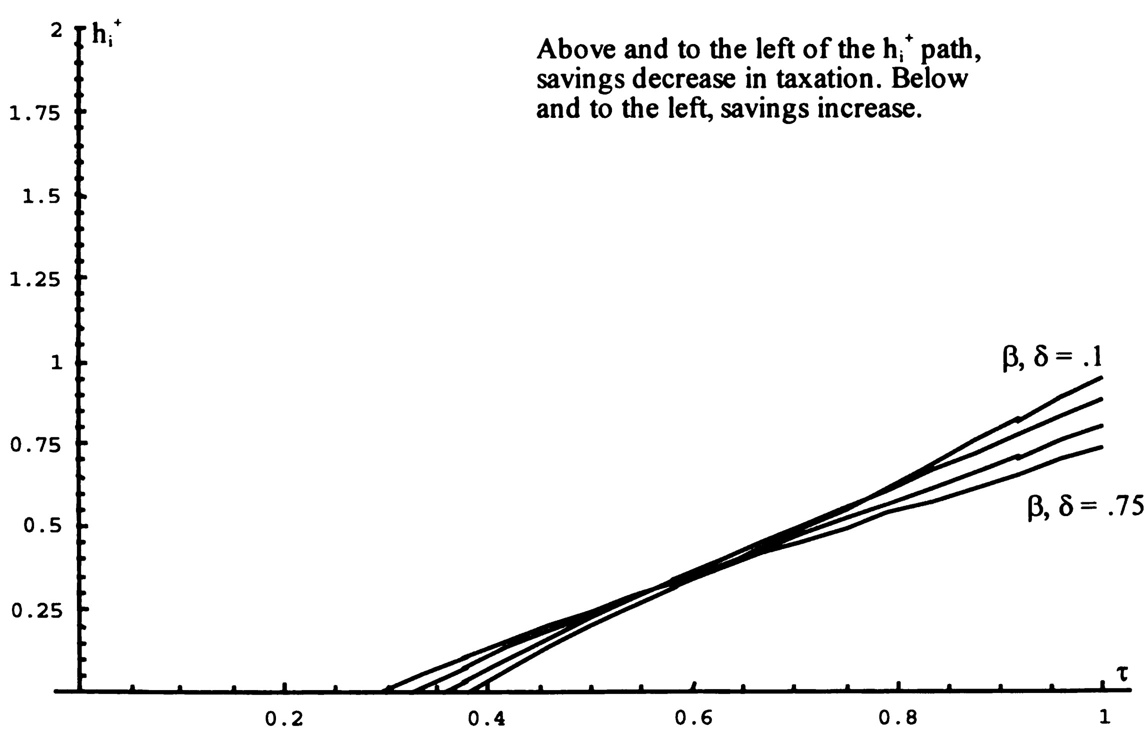

Figure 1 Savings equilibrium, as a function of taxation and income group

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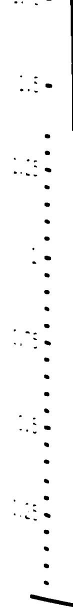
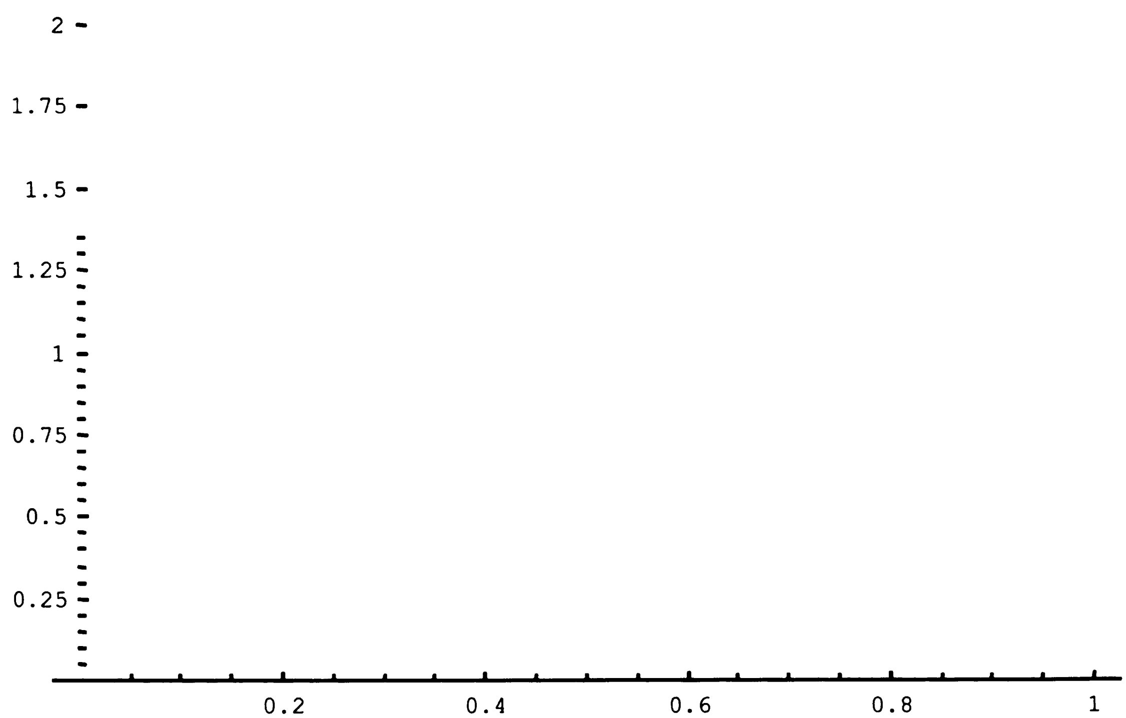


Likewise, it is possible to construct h_i^{++} the productivity requirement such that bequests will fall in taxation. Plotting h_i^{++} against τ for combinations of β and δ ranging from .1 to .75 (assuming α = .3), it is again clear that the path of h_i^{++} is not critically dependent on changes in β and δ, and that for any reasonable parameter set, at low tax levels all agents' bequests increase in taxation, and even at high tax rates only high productivity agents may have bequests which fall in taxes.



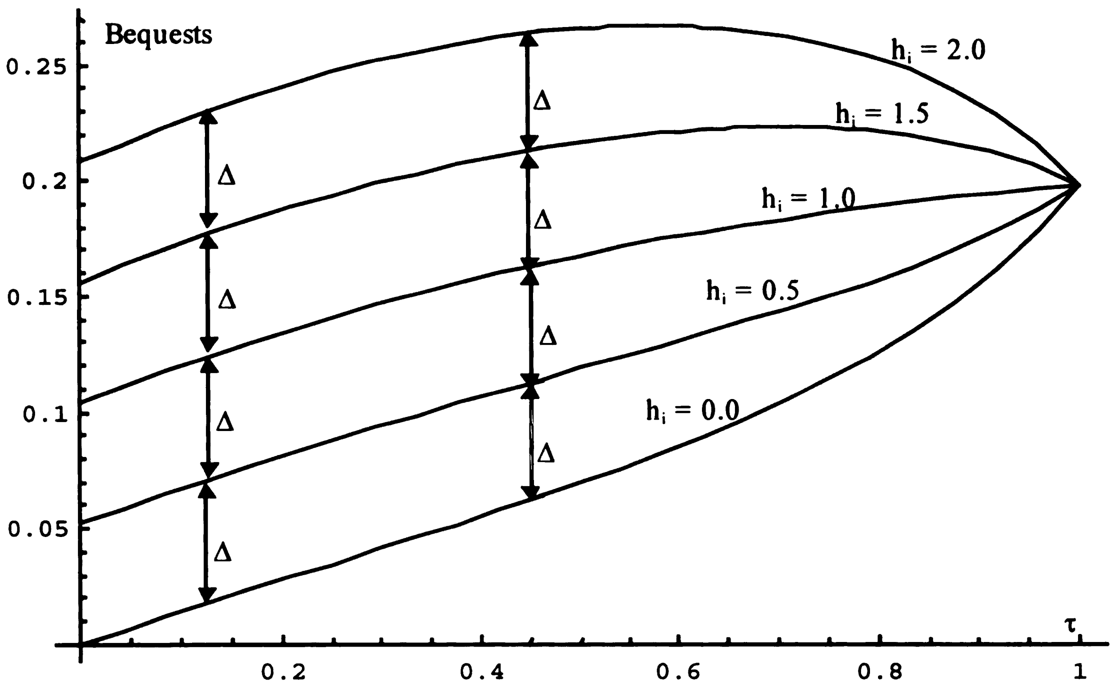


Figure 3 The level of bequests, as a function of taxation and income group

Clearly, for low income groups, bequests consistently rise in taxation, while for high productivity groups, bequests initially rise, but later fall.

Appendix 2

The nature and robustness of agents' bliss points

As has been stated, the nature of τ_{iy}^* and τ_{io}^*, the bliss points of young and old agents of type i, remains analytically insoluble, due to the nonlinear form of $U_{Pit}[\tau_t]$. As such, it is necessary to numerically solve the model at this point.

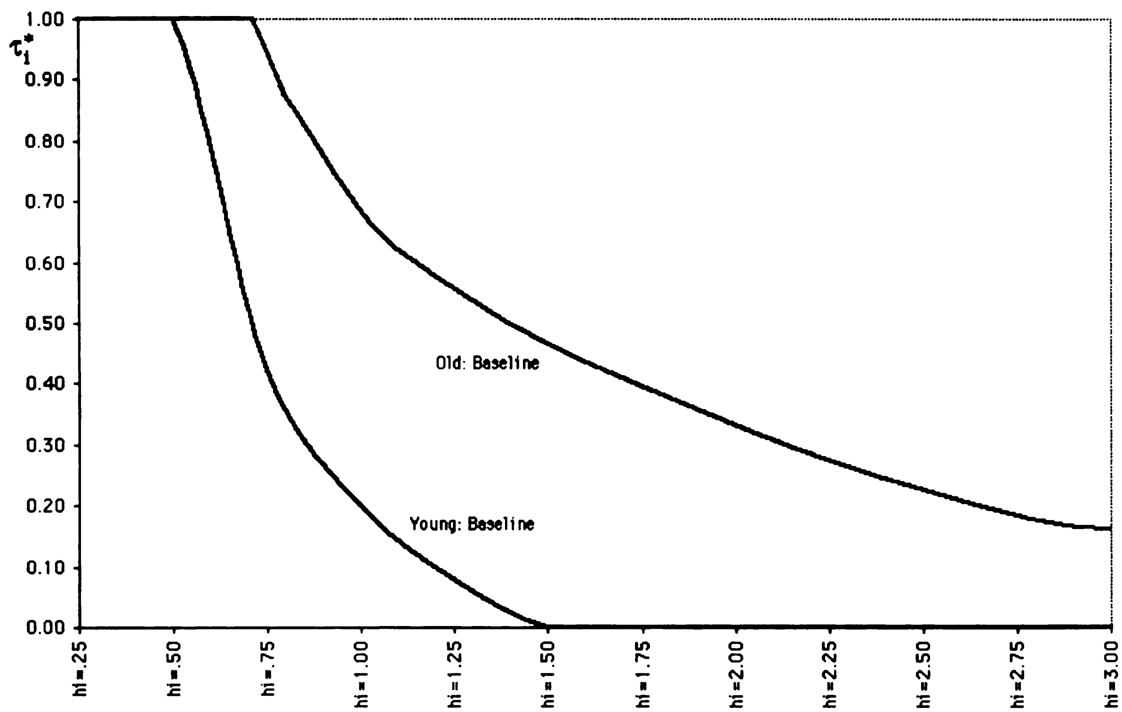


Figure 4 The distribution of bliss points under baseline parameters.

As can be seen by comparing the figure above (simulated under baseline conditions) to those given in Figure 4, although these parameter changes *do* have a significant effect on the *location* of a given agent's bliss point, the general pattern described in proposition 2, Eq.s 5.3 and 5.4 remains valid across a very wide range of parameter values.

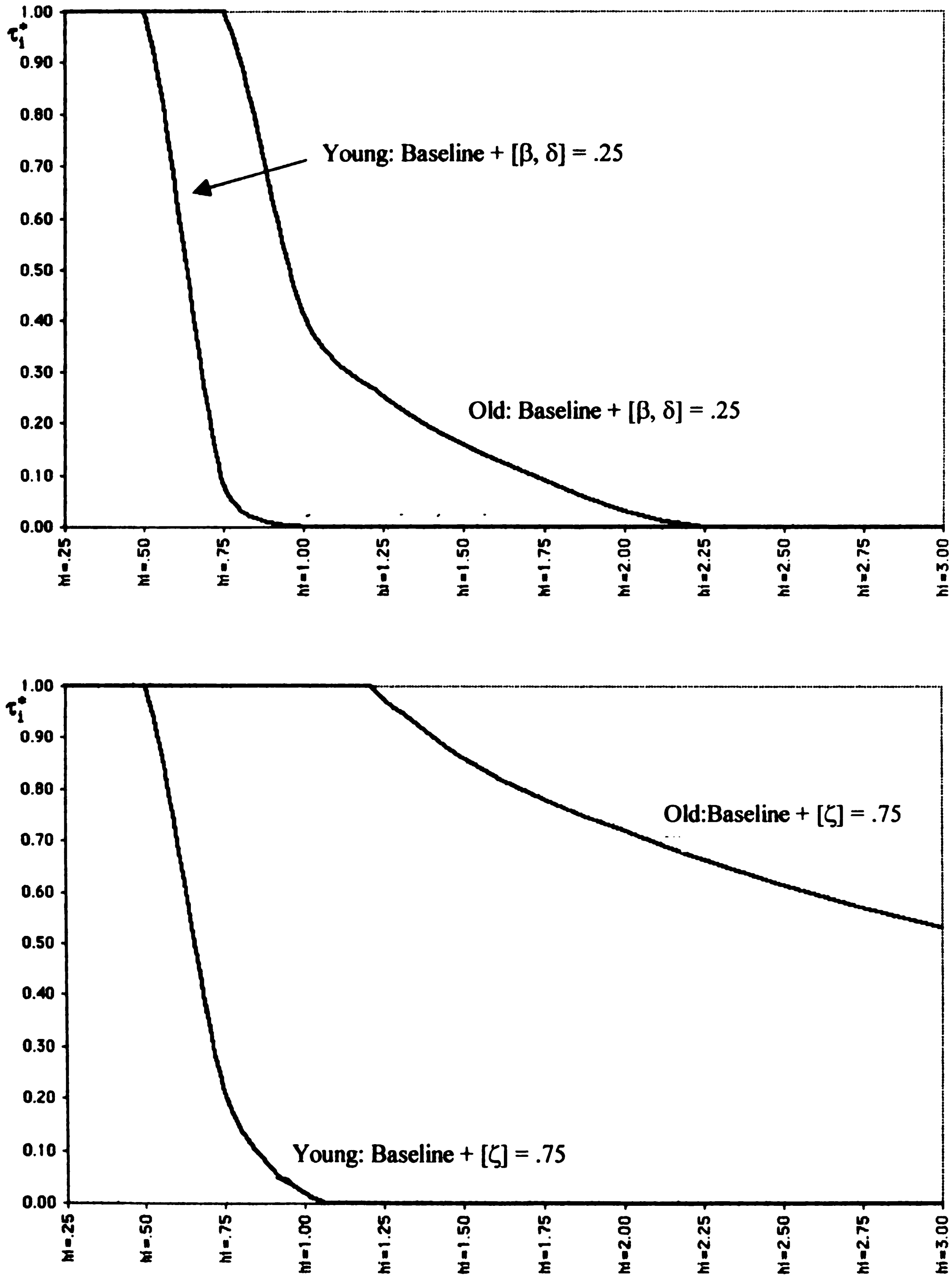


Figure 5 **Class- and age-dependent distributions of voter bliss points under various parameter sets.**

Appendix 3

Changing dominant strategies across different parameter spaces

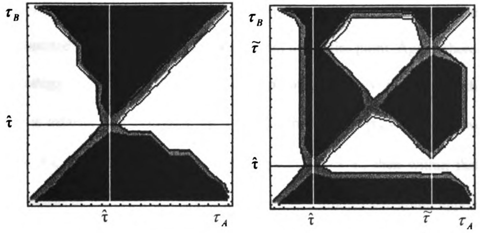


Figure 6 Typical Nash strategy plots for centrist (*left*) and polarized (*right*) games. Infinite strategy normal forms of the electoral game, for a highly homogeneous population.

In each plot, the strategy chosen by candidate A is marked on the vertical axis, and that chosen by candidate B is on the horizontal axis. Strategy combinations $\{\tau_A, \tau_B\}$ such that A wins are shown in white, whereas strategy combinations such that B wins are shown in black. Combinations which yield identical or near-identical tallies for each candidate are shown in grey.

Clearly, a weakly dominant strategy for candidate A would yield a horizontal slice of the normal form in which, irrespective of candidate B's strategy, A would win or tie. Likewise, a dominant strategy for B would generate a vertical line along which A always lost, or at best tied.

In the first frame, where information costs (and hence disutility and alienation) are zero, and thus almost all agents vote, the median voter theorem result occurs. In this frame, the dominant strategies are $\tau_A = \tau_B = \hat{\tau}$. In any restricted strategy space such that $\hat{\tau}$ is not available as a strategy, the dominant strategy will be binding against the edge of the available strategy space closest to $\hat{\tau}$.

In the second frame, however, information costs are significant, and agents are alienated by policy platforms distant from their bliss point. Again, there exists a dominant strategy, $\hat{\tau}$, which will beat or match any other strategy. However, although the strategy, $\tilde{\tau}$ is inferior to $\hat{\tau}$, (in that the strategy combination $\{\tau_A = \hat{\tau}, \tau_B = \tilde{\tau}$ would yield victory for A), if the strategy set is restricted to $\tau_{min} >> \hat{\tau}$, then within that restricted space, $\tilde{\tau}$ would be the dominant strategy, rather that a binding constraint approaching $\hat{\tau}$.

Chapter 3. Does Medicare make Us Healthy?

Section I: Introduction

Medicare was established in 1965 to improve the health care available to and healthiness of elderly Americans. The policy was, essentially, redistributive, transferring resources from the working young to the retired old. It has achieved its health care goals, but at what cost? To evaluate this cost, it is not only necessary to examine the direct costs of the system, but the indirect costs as well. Many studies have looked at various ways to make the program cheaper and more effective (see, for example, Moon (1993), Mazo, et al. (1994), Aaron and Reischauer (1995) and Moon and Davis (1995)). Few have examined the indirect costs. A notable exception is Wolfe (1993). These indirect costs may be substantial if people during their working years postpone health maintenance until their retirement, or, at least, reduce their expenditures on health maintenance in response to the difference in the price of maintaining their health now relative to the price of maintaining it once retired, and/or in response to their lower after-Medicare-tax income. If people decrease their health care spending in their prime working years, then they will be less productive during their work life, and they will enter their retirement less healthy and less wealthy than they would in the absence of the Medicare system. Thus, the demand for health care by the elderly may be higher than would have otherwise been the case, and so the cost of maintaining the system could be higher. A higher cost will lead to increased taxes on the young, reducing their after tax incomes and their ability to invest in their own health creating a vicious cycle.

This paper develops an overlapping generations model (following Allais (1947), Samuelson (1958), and Diamond (1965)) in which agents value health for both utility and human capital enhancing reasons, as in Grossman (1972). Agents are assumed to be two period lived, working in the first period, being retired in the second period. There are two types of agents: high initial health status and low initial health status. High health status is assumed to reflect high productivity and therefore high income. Young agents of both types get utility from consumption and healthiness. Further, their income is a function of their human capital which depends on their healthiness. The old get utility from consumption and healthiness as well. Healthiness while old depends not only on health maintenance while old, but also on health maintenance while young. The young work, pay social security and Medicare taxes, and allocate their after tax earnings to consumption, health maintenance, and saving for retirement. Health can be maintained via investments in medical and non-medical care. Medical care may be subsidized by the government. The old are retired. One lives throughout retirement with probability p, which is type dependent, and dies at the onset of retirement with probability (1-p). Retirees allocate the after tax return on their savings and their social security benefits to consumption and health maintenance. Medical care for the old is subsidized by the government. These subsidies are funded by the taxes on the labor income of the young and by taxes on the return to saving of the old or by lump sum taxes on the old; these taxes are endogenous. Social security benefits are calculated as a percentage of earnings while young. These benefits are funded by taxes on the labor income of the young and taxes on the return to saving of the old or lump-sum taxes on the old; these taxes are also endogenous. All savings of the short-lived old are left to their children. These bequests are also taxed.

Previewing some of the results of the model: (i) a reduction in the price of health care for the working population, either directly or via subsides, may increase steady-state hea

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healthiness of workers and retirees of both types, and may increase capital accumulation; (ii) an increase in the Medicare subsidy rate need not improve the steady-state healthiness of retirees, reduces the healthiness of the young and of the population on average, and reduces capital accumulation; (iii) increasing the elderly's share of the cost of the Medicare system may improve the steady-state healthiness of workers and retirees, and may increase capital accumulation.

Section II: The Model

Consider an infinitely-lived economy composed of two types of finitely-lived individuals, and a government. The two types of agents differ in their productivity or underlying health status. A new generation of each type of individual is born at the beginning of each period t, (t = 1, 2, 3....) and lives for two periods: youth and retirement. Call this generation t and index type by i, i = 1, 2. Individual agents of each type are *ex ante* identical, and face a type specific probability of death at the onset of retirement of $(1-p^i) \in [0, 1]$. There is no population growth. Without loss of generality assume N^1 of type 1 and N^2 agents of type 2 are born at each date, $N^1 + N^2 = 1$.

Both types of agents in the first period of their lives work and divide their income (labor income plus bequests) among current consumption, current health maintenance, saving for old age, and payment of social security and Medicare taxes. An agent's health maintenance expenditures while young enhance his human capital, and thus augment his effective labor. There are two types of health maintenance expenditures: medical and non-medical. The former may be subsidized by the government. The latter can be thought of as expenditures on exercise, nutrition, etc. Such life-style factors have been shown to be important determinants of health status by Gilleskie and Harrison (1998) and Kenkel (1991), among others. Furthermore, non-medical efforts at one point in time may reduce the need for subsequent medical expenditures, as explored by Grembowski (1993) and Stearns et al. (1998). Although there is not a within-generational link between medical and non-medical expenditures, there is a cross-generational link between expenditures on health inputs and health status in this model.

At the beginning of the second period of a type i agent's life he either lives, with probability p^i, or dies, with probability $(1-p^i)$.[14] Agents alive in the second period of their lives are retired. They divide their after tax returns to saving and their social security benefits between consumption and health care; the medical care component of health care is subsidized by the Medicare program. Agents who die at the onset of retirement bequeath their wealth to their children who are of the same type as their parents.[15] This assumption allows the health distribution (or income distribution) to remain constant over

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[14] Agents in this model face uncertainty about the time of death but not about the maximum possible length of life. This implies that agents may die before they have exhausted their non-social security wealth, but not vice versa.

[15] Bequests in this model are assumed to be unintentional, a function of not knowing one's date of death, rather than of the desire to make one's children better off. This assumption is consistent with findings by numerous researchers: see Hurd (1990), Auerbach, Kotlikoff, and Weil (1992), and Börsch-Supan (1993), as well as the empirical findings of Altonji, Hayashi, and Kotlikoff (1992) that parents and their adult children are not altruistically linked. But, other research finds an operative bequest motive (Hamermesh

time. This also simplifies the model by not having agents that are of a different type then their parents, as otherwise the bequests would drive the results by generating the income distribution over time.

Let the representative type i member of generation t's preferences be represented by

$$U^i(t) = \ln h_t^{yi}(t) + \ln c_t^i(t) + p^i \ln h_t^{oi}(t+1) + p^i \ln c_t^i(t+1)$$

where $h_t^{yi}(t)$ is the health of a type i member of generation t while young, $c_t^i(t)$ is consumption of goods by a type i member of generation t while young, $h_t^{oi}(t+1)$ is the health of a type i member of generation t while old, and $c_t^i(t+1)$ is the consumption of goods by a type i member of generation t while old.

Assume that a young type i member of generation t's health is an increasing concave function of his medical expenditures on health maintenance, $m_t^i(t)$, and his non-medical expenditures on health maintenance, $e_t^i(t)$. In particular, assume $h_t^{yi}(t) = \xi^{yi} m_t^i(t)^{\mu_1^i} e_t^i(t)^{\nu_1^i}$, where $\mu_1^i \in [0,1]$ and $\nu_1^i \in [0,1]$, $\xi^{yi} > 0$. ξ^{yi} can either be considered the initial health stock of the person when he is young, or equivalently, it can represent his initial productivity type. Assume further that an old member of generation t's health is an increasing function of health while young and health maintenance expenditures, both medical and non-medical, while old, $m_t^i(t+1)$ and $e_t^i(t+1)$,

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and Menchik (1987) and Hurd (1995)), at least among the wealthy. Since the jury is still out, the assumption of unintentional bequests will be maintained.

respectively. Assume $h_t^{oi}(t+1)=\xi^{oi}m_t^i(t+1)^{\mu_2^i}e_t^i(t+1)^{\nu_2^i}h_t^{yi}(t)^{\beta^i}$ where $\mu_2^i\in[0,1]$ and $\nu_2^i\in[0,1]$ and $\beta^i\in[0,1]$, $\xi^{oi}>0$. ξ^{oi} is an age-specific shift to health.

The firms in this economy are perfectly competitive profit maximizers that produce a single consumption good using the constant returns to scale production function $Y(t)=A(t)K(t)^{\alpha}H(t)^{1-\alpha}$, where $A(t)>0$ is a productivity constant, $K(t)$ is the capital stock at date t, $H(t)=\sum_i N^i(t)h_t^{yi}(t)$ is effective labor at date t which is comprised of labor hours, $N^i(t)$ of each type of agent, the productivity of which is augmented by the workers' health, $h_t^{yi}(t)$. Assume physical capital depreciates fully in the production process.[16]

Young type i agents produce medical health goods by converting current consumption goods into medical health care at a constant rate γ_{m1}^i, and produce non-medical goods by converting current consumption goods into non-medical health care at a constant rate γ_{e1}^i. The government may subsidize the medical health care costs of the young. If so, the type i young pay only $(1-\sigma^i)\%$ of their medical costs, the other $\sigma^i\%$ is paid by the government. Type i old agents produce non-medical health care by converting consumption goods into non-medical health goods at a constant rate γ_{e2}^i. They produce medical health care by converting consumption goods into medical health goods at a constant rate γ_{m2}^i. Under Medicare financing of the medical care of the old,

[16] The production process is over the course of a generation. Since empirically the depreciation rate is about 10% per year, capital is all but fully depreciated over the course of a 30 year generation.

type i old agents only pay $(1-\theta^i)$% of their medical care costs, while the other θ^i% is paid by the government; θ is the Medicare subsidy rate. The Medicare program does not currently differentiate benefits by income, but one may view a higher level of θ as analogous to the subsidy for the dually-eligible elderly who are enrolled in both Medicare and Medicaid. Although the subsidy rate would be the same for all non-Medicaid eligible elderly, the non-Medicaid eligible elderly can effectively lower their out-of-pocket medical price by purchasing Medigap insurance, which we do not model. Allowing θ to vary by agent type allows for policy simulations of the effect of transforming Medicare into an income-related program.

The government in this economy imposes a proportional, type specific, tax on the wages of young workers, $\tau_1^i(t)$, and a proportional, type specific, tax on the return on savings of the old, $\tau_2^i(t)$, and/or a lump-sum, type specific, tax on the old, $\ell^i(t)$. The revenues from these taxes support both the social security system and the Medicare system. Social security benefits are determined as a type specific fixed proportion, ζ^i, of labor income while young. The Medicare system sets the type specific subsidy rate on health care expenditures of the old, θ^i, and the level of benefits is determined by the old's medical care expenditures. The government funds its current expenditures with current tax receipts, as under the current OASDI and Medicare programs.[17] Thus, it must adjust the tax rates to ensure that its budget always balances.

[17] These programs are required to be in balance over the 75 year planning horizon. We impose the funding balance requirement generationally.

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The representative type i agent at date t takes as given the return on saving when old, $(1+\rho(t+1))$, the tax rates $\tau_1^i(t)$ and $\tau_2^i(t+1)$ and/or $\ell^i(t+1)$, social security benefits T(t+1), and bequests B(t). He chooses health care expenditures while young, $m_t^i(t)$ and $e_t^i(t)$, and old, $m_t^i(t+1)$ and $e_t^i(t+1)$, and saving, $s^i(t)$, to maximize

1. $\ln h_t^{yi}(t) + \ln c_t^i(t) + p^i \ln h_t^{oi}(t+1) + p^i \ln c_t^i(t+1)$

subject to

2. $h_t^{yi}(t) = H^{yi} m_t^i(t)^{\mu_1^i} e_t^i(t)^{\nu_1^i}$

3. $h_t^{oi}(t+1) = H^{oi} m_t^i(t+1)^{\mu_2^i} e_t^i(t+1)^{\nu_2^i} h_t^{yi}(t)^{\beta^i}$

4. $c_t^i(t) = h_t^{yi}(t)(1-\tau_1^i(t)) + \mathrm{B}^i(t) - s^i(t) - \gamma_{m1}^i(1-\sigma^i)m_t^i(t) - \gamma_{e1}^i e_t^i(t)$

5. $c_t^i(t+1) = (1+\rho(t+1))(1-\tau_2^i(t+1))s^i(t) + T^i(t+1)$

$$-\ell^i(t+1) - \gamma_{m2}^i(1-\theta^i)m_t^i(t+1) - \gamma_{e2}^i e_t^i(t+1)$$

where constraint 4 encompasses the assumption that bequests are allocated equally across all members of a type in a generation so that the bequest dependent wealth distribution is uniform as in Hubbard and Judd (1987). This assumption maintains the within type representative agent assumption throughout time. Constraint 5 includes the assumption that agents do not know the functional linkage between their work effort today and their social security benefits when old. This follows from the fact that social security benefits have both insurance and redistributive components, so increasing one's wage income rodi

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today and paying more social security taxes may not lead to proportionately higher benefits tomorrow.[18]

Substituting constraints 2 - 5 into the objective function 1 and maximizing yields the first-order conditions of the type i agent's problem with respect to medical goods and non-medical goods while young, medical goods and non-medical goods while old, and saving, respectively.

6. $$\frac{\mu_1^i(1+p^i\beta^i)}{m_t^i(t)}+\frac{\mu_1^i H^{\gamma i} m_t^i(t)^{\mu_1^i-1} e_t^i(t)^{\nu_1^i}(1-\tau_1^i(t))-\gamma_{m1}^i(1-\sigma^i)}{c_t^i(t)}=0$$

7. $$\frac{\nu_1^i(1+p^i\beta^i)}{e_t^i(t)}+\frac{\nu_1^i H^{\gamma i} m_t^i(t)^{\mu_1^i} e_t^i(t)^{\nu_1^i-1}(1-\tau_1^i(t))-\gamma_{e1}^i}{c_t^i(t)}=0$$

8. $$\frac{\mu_2^i}{m_t^i(t+1)}-\frac{\gamma_{m2}^i(1-\theta^i)}{c_t^i(t+1)}=0$$

9. $$\frac{\nu_2^i}{e_t^i(t+1)}-\frac{\gamma_{e2}^i}{c_t^i(t+1)}=0$$

10. $$-\frac{1}{c_t^i(t)}+\frac{p^i(1+\rho(t+1))(1-\tau_2^i(t+1))}{c_t^i(t+1)}=0.$$

To simplify the analysis, equations 6 and 7 can be combined to solve for $e_t^i(t)$ as a function of $m_t^i(t)$:

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[18] Further, while it is true that the Social Security Administration will provide future benefit information to workers based on their lifetime earnings up to that point, they will not provide a schedule of how changing one's current income by working more hours or by increasing one's human capital, and thus wage, will affect one's future benefits. This also suggests that individuals make human capital investment decisions without reference to the effects thereof on their Social Security benefits.

11. $$e_t^i(t) = \frac{v_1^i}{\mu_1^i}\frac{(1-\sigma^i)\gamma_{m1}^i}{\gamma_{e1}^i} m_t^i(t),$$

while equations 8 and 9 can be combined to solve for $e_t^i(t+1)$ as a function of $m_t^i(t+1)$:

12. $$e_t^i(t+1) = \frac{v_2^i}{\mu_2^i}\frac{(1-\theta^i)\gamma_{m2}^i}{\gamma_{e2}^i} m_t^i(t+1);$$

non-medical goods and medical goods are consumed in fixed proportions while young and old. Using equations 12 and 8, $m_t^i(t+1)$ can be solved as a function of income when old

13. $$m_t^i(t+1) = \frac{v_2^i}{\gamma_{e2}^i(1+v_2^i+\mu_2^i)}[(1+\rho(t+1))(1-\tau_2^i)s^i(t) + T^i(t+1) - \ell^i(t+1)]$$

Equations 6, 10, 11, and 13 can be combined to yield a system of two equations in two unknowns, $m_t^i(t)$ and $s^i(t)$, which fully characterizes the type i agent's problem.

The representative firm takes wages and rental rates as given. It hires effective labor and capital until their marginal products equal their factor prices.

14. $$(1-\alpha)A(t)K(t)^{\alpha} H(t)^{-\alpha} = (1-\alpha)A(t)k(t)^{\alpha}[N^1 h_t^{y1}(t) + N^2 h_t^{y2}(t)]^{-\alpha_1} = w(t)$$

15. $$\alpha A(t)K(t)^{\alpha-1} H(t)^{1-\alpha} = \alpha A(t)k(t)^{\alpha-1}[N^1 h_t^{y1}(t) + N^2 h_t^{y2}(t)]^{(1-\alpha)} = r(t)$$

where $k(t)$ is the capital labor-hours ratio. Because of the assumption of constant returns to scale and agents' inelastic supply of effective labor, equations 14 and 15 also define factor market clearing.

The government must maintain a balanced budget at each date t. To do this it must adjust taxes to meet the Medicare subsidy bill,

$$N^1 p^1 \gamma_{m2}^1 \theta^1 m_{t-1}^1(t) + N^2 p^2 \gamma_{m2}^2 \theta^2 m_{t-1}^2(t),$$

its subsidy of the medical care of the young,

$$N^1\gamma^1_{m1}\sigma^1 m^1_t(t) + N^2\gamma^2_{m1}\sigma^2 m^2_t(t),$$

as well as the social security benefit bill,

$$T^1(t) + T^2(t) = p^1 N^1 \zeta^1 h^{y1}_{t-1}(t-1)w(t-1) + p^2 N^2 \zeta^2 h^{y2}_{t-1}(t-1)w(t-1).$$

That is, at time t the government must set $\tau^1_1(t)$, $\tau^2_1(t)$, $\tau^1_2(t)$, $\tau^2_2(t)$, $\ell^1(t)$ and $\ell^2(t)$ to satisfy

16. $$N^1 h^{y1}_t(t)\tau^1_1(t) + N^2 h^{y2}_t(t)\tau^2_1(t) + N^1\tau^1_2(t)(1+\rho(t))s^1(t-1)$$
$$+N^2\tau^2_2(t)(1+\rho(t))s^2(t-1) + p^1 N^1 \ell^1(t) + p^2 N^2 \ell^2(t) =$$
$$N^1 p^1 \gamma^1_{m2}\theta^1 m^1_{t-1}(t) + N^2 p^2 \gamma^2_{m2}\theta^2 m^2_{t-1}(t) +$$
$$N^1\gamma^1_{m1}\sigma^1 m^1_t(t) + N^2\gamma^2_{m1}\sigma^2 m^2_t(t) + p^1 N^1 \zeta^1 h^{y1}_{t-1}(t-1) + p^2 N^2 \zeta^2 h^{y2}_{t-1}(t-1).$$

Clearly, given the Medicare subsidy rates, the subsidy rates on the health care of the young, and the social security replacement rates, the government is only free to choose five of the six taxes.

If a type i agent dies at the onset of retirement, his saving is bequeathed in full to his heirs who must then pay tax on their inheritance. To maintain the representative agent formulation bequests are equally divided among all the young of the same type

17. $$B^i(t) = (1-p^i)(1+\rho(t))(1-\tau^i_2(t))s^i(t-1).$$

The goods market clears when demand for goods equals supply of goods. Goods market clearing implies that the saving of the young today totally determines the capital stock tomorrow.

18. $$N^1 s^1(t-1) + N^2 s^2(t-1) = Nk(t)$$

Also, by arbitrage

19. $$(1+\rho(t)) = r(t).$$

Section III: Steady-state Equilibrium

A competitive steady-state equilibrium for this economy is a time invariant price vector $\{w, r, \rho\}$, a time invariant allocation $\{m^{yi}, m^{oi}, e^{yi}, e^{oi}, c^{yi}, c^{oi}, s^i;\ \mathrm{i} = 1{,}2\}$, such that given these prices and allocations agents' utility is maximized, firms' profits are maximized, and the government's budget constraint is satisfied.

Equations 6, 10 - 15 and 17, for both types of agents, and 16, 18 and 19 defined at steady-state characterize the steady-state equilibrium. Steady-state equilibrium is represented by

20. $\mu_1^i(1 + p^i\beta^i)c^{yi} + \mu_1^i h^{yi} w(1-\tau_1^i) - \gamma_{m1}^i(1-\sigma^i)m^{yi} = 0,\ \mathrm{i} = 1, 2$

and

21. $-c^{oi} + p^i r(1-\tau_2^i)c^{yi} = 0,\ \mathrm{i} = 1, 2$

where

$$\begin{aligned} c^{yi} &= (1-\alpha)A(N^1s^1 + N^2s^2)^{\alpha}(N^1h^{y1} + N^2h^{y2})^{-\alpha}h^{yi} \\ &\quad + (1-p^i)(1-\tau_2^i)\alpha A(N^1s^1 + N^2s^2)^{\alpha-1}(N^1h^{y1} + N^2h^{y2})^{1-\alpha}s^i \\ &\quad - s^1 - \gamma_{m1}^i(1-\sigma^i)\left(\frac{\mu_1^i + \nu_1^i}{\mu_1^i}\right)m^{yi} \quad \mathrm{i} = 1{,}2 \end{aligned}$$

$$c^{oi} = \left[\frac{1}{1 + \mu_2^i + \nu_2^i}\right][(1-\tau_2^i)rs^i + \zeta^i h^{yi} w - \ell^i],\ \mathrm{i}=1{,}2$$

$$h^{yi} = \xi^{yi}\left(\frac{\gamma_{m1}^i(1-\sigma^i)}{\gamma_{e1}^i}\frac{\nu_1^i}{\mu_1^i}\right)^{\nu_1^i}(m^{yi})^{\mu_1^i + \nu_1^i},\ \mathrm{i}=1{,}2$$

$$w = (1-\alpha)A(N^1s^1 + N^2s^2)^{\alpha}(N^1h^{y1} + N^2h^{y2})^{-\alpha}$$

$$r = \alpha A(N^1s^1 + N^2s^2)^{\alpha-1}(N^1h^{y1} + N^2h^{y2})^{1-\alpha}$$

and given the other tax and subsidy rates τ_1^1 solves

$$N^1 h^{y1}\tau_1^1 + N^2 h^{y2}\tau_1^2 + N^1\tau_2^1 rs^1 + N^2\tau_2^2 rs^2 + p^1 N^1 \ell^1 + p^2 N^2 \ell^2 =$$

$$N^1 p^1 \gamma_{m2}^1 \theta^1 m^{o1} + N^2 p^2 \gamma_{m2}^2 \theta^2 m^{o2} + N^1 \gamma_{m1}^1 \sigma^1 m^{y1} + N^2 \gamma_{m1}^2 \sigma^2 m^{y2} +$$

$$p^1 N^1 \zeta^1 h^{y1} + p^2 N^2 \zeta^2 h^{y2}.$$

Equations 20 and 21, while not analytically tractable, can be solved numerically for the version of the model that most closely resembles the real world: the tax rate on the young, $\tau_1^i = \tau_1 \forall i$, adjusts to keep the government budget constraint balanced given the taxes on the income of the old and lump sum taxes on the old. The baseline set of parameters, listed in Exhibit 1, were chosen for the following reasons. For the price of medical care for the young, γ_{m1}^i, we use the ratio of the CPI for medical care to the CPI, which is approximately 1.5 (US Bureau of Labor Statistics, 1995). We assume that the price of non-medical care, γ_{e1}^i, is lower both than the price of overall consumption and medical care, since much non-medical care, such as exercise is free. Since the price of medical care to the old, in terms of provider reimbursement, is somewhat lower than the price charged for the same service to the young, we set γ_{m2}^i to 1.25, while leaving the price of non-medical care for the old equal to that of the young. The Medicare subsidy rate, θ, is, approximately, the share of medical health care expenditures (not including nursing home expenditures) by the old that are paid for by Medicare or other public programs (Hahn and Lefkowitz, 1992). The social security replacement rate, ζ^1 (ζ^2), is, according to the Office of the Chief Actuary of the Social Security Administration, .42 for the average earner (.65 for the low wage earner). The Office of the Chief Actuary of the Social Security Administration has also estimated the current aged-dependency ratio to t

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to be in the neighborhood of .2. We duplicate this by assuming 70% of the population is comprised of type 1 agents who have a probability of living into old age, p^1, of .215, and that 30% of the population is comprised of type 2 agents who have a probability of living into old age, p^2, of .165. (In other words, $N^1p^1+N^2p^2=0.2$.) The tax on the return to saving was chosen initially to be equal to 10% for both types of agents since the average elderly individual falls into a lower tax bracket than the average young individual. We hold the lump sum tax to zero. The ξs, μs, νs and β were jointly chosen to yield a ratio of health care expenditures by the old to health care expenditures by the young in excess on unity, as found in the data (Hahn and Lefkowitz, 1992).

The remainder of this section contains simulation results that summarize the comparative static properties of the model. The first set pertain to policy parameters: the Medicare subsidy rates, the social security replacement rates, and the tax rates, while the others examine the cost of medical care, the cost of non-medical care, and the demographic variables. Among the variables that are potentially affected, we focus on the implications for capital and health levels because of the relevance of these variables for the well-being of both the young and the old.

Result 1: (a) Economies with more generous Medicare systems for high productivity (type 1) agents, higher θ^1, have lower rates of saving, thus lower capital, less healthy young of both types, healthier type 1 old, less healthy type 2 old, healthier old on average, and a less healthy population overall. (b) Economies with more generous Medicare systems for low productivity (type 2) agents, higher θ^2, have lower rates of saving, thus lower capital, less healthy young of both types, healthier type 2 old, less hea

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healthy type 1 old, first more then less healthy old on average, and a less healthy population overall.

An increase in the Medicare subsidy rate for either type of agent reduces after tax lifetime income for both types of agent. Agents respond to this reduction in their income by decreasing their expenditures across the board, which reduces their income further since this reduces their human capital investment via both medical and non-medical care. Further, by reducing the price of health maintenance when old, the relative prices of capital and health maintenance while young are increased. So agents substitute away from the now more expensive goods. The reduction of healthiness and capital accumulation when young reduces income when old. However, since the price of health care when old is now relatively lower for the targeted group, the old of that group spend a higher proportion of their (lower) income on health care. While the policy does improve the health of the targeted group, it does so at the cost of reducing overall healthiness. See Tables 1a and 1b.

Two policy ramifications follow from these results. First, roughly 16 percent of the Medicare population is dually eligible for Medicare and Medicaid (Aaron and Reischauer, 1995). The Medicaid program may, at some level, be interpreted as constituting a higher θ^2 for Type 2 agents. Second, even in the absence of the Medicaid program, the proposal to means test Medicare benefits is equivalent in this model to a reduction in the Medicare subsidy rate for the type 1 agents, as they have higher incomes when old than type 2 agents. While this leads to a reduction in healthiness of the old, on average, in steady state, it improves the health of the low health old. Further, it reduces the

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the tax burden on all the young, increasing their investment in capital and health maintenance, thereby increasing the income of the old and hence their ability to invest in their own health maintenance. See Table 1a.

Result 2: (a) Holding the comparative generosity of the Medicare system constant, $\theta^2 - \theta^1$ constant, economies with higher Medicare subsidy rates have lower rates of saving, so lower capital, less healthy young agents of both types, more healthy type 1 old, less healthy type 2 old, higher average health of the old, but lower healthiness of the population overall. (b) Holding the relative generosity of the Medicare system constant, θ^1 / θ^2 constant, economies with higher Medicare subsidy rates have lower rates of saving, therefore capital, less healthy young of both types, more healthy old of type 2, more healthy type 1 and average old, and a less healthy population overall. (c) Let $\theta^1 = \theta^2$, economies with higher Medicare subsidy rates have lower rates of saving, therefore capital, less healthy young of both types, first more then less healthy old of both types, and a less healthy population overall.

As is shown in Table 2a, a policy of holding the comparative generosity of the Medicare system constant biases the system towards the type 1 old as their subsidy rate rises at a faster rate than that of the type 2 old. However, both groups of young see their tax rates rising at the same rate. Consequently, type 2 agents are made worse off in every dimension, since their lower after tax income reduces their expenditures across the board, and reduces their saving so as to leave them with so much less to spend while old, even at the lower prices, that their medical expenditures fall. While the type 1s do benefit in old age

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age from the higher Medicare subsidy rate, the population as a whole is made less healthy. In contrast, a policy of holding the relative generosity of the system constant favors the type 2 old across the board, and at most subsidy rates the type 1 old benefit as well, as shown in Table 2b. This difference results from the second policy being less generous than the first, which imposes lower taxes on the young, so they invest more in their human capital, are more productive (and higher productivity by one group benefits all), and thus enter old age relatively healthier. However, the better health when old is bought by worse health when young.

Examination of Tables 2c(i) and 2c(ii) show that increases in the uniform Medicare subsidy rate first lead to an improvement in the health of the old of both types up to a subsidy rate of approximately .75; further increases lead to a worsening of the health of the old (although expenditures on health maintenance by the old continue to rise). These simulation results therefore suggest that the designers of the Medicare system may have optimized the benefit to the elderly by not providing first dollar coverage for all services. Since the health of the young and the average health of all members of the economy are unambiguously improved by decreasing the Medicare subsidy rate, reining in the Medicare system may lead to improvements in the overall health and productivity of the economy for a relatively low concomitant reduction in the health of the elderly. It is true that beneficiaries may avoid the first dollar coverage or some increases in beneficiary liability by purchasing supplemental insurance. Indeed, roughly 65 percent of Medicare beneficiaries have other or supplemental insurance that covers Medicare deductibles and coinsurance, and 16 percent of beneficiaries have coverage of these amounts through Medicaid. However, since θ^2 represents the *government's* subsidy of health care for the elderly, these additional sources of coverage have more to do with the relative price faced by the elderly than with the government subsidy *per se*.

Result 3: (a) Economies with higher Social Security replacement rates for high productivity (type 1) agents, higher ζ^1, holding the replacement rate for type 2 agents constant, have first higher then lower rates of saving for type 1 agents, lower rates of saving for type 2 agents, and lower rates of capital accumulation overall, first more then less healthy type 1 young and old, lower average health of the young, first higher then lower average health of the old, and less healthy type 2 young and old. (b) Economies with higher Social Security replacement rates for low productivity (type 2) agents, higher ζ^2, holding the replacement rate for type 1 agents constant, have lower rates of saving for type 1 agents, higher rates of saving for type 2 agents, lower rates of capital accumulation, less (more) healthy type 1 (type 2) young and old, and less healthy old and young on average.

While counterintuitive, saving may rise with the replacement rate since lifetime income, for type 1 agents at low replacement rates, and for type two agents at all replacement rates, rises initially with the replacement rate. As a result, all expenditures rise, compounding the positive income effect. It is via this mechanism that average health of the population can be improved via a more generous Social Security System for the healthy (rich), but this is financed by making the unhealthy (poor) worse off (the poor share in the costs without receiving any more of the benefits). Higher replacement rates for the poor do improve the lives of the poor, but now since the rich do not receive a share of the expanded benefits, overall health is not improved. See Tables 3a and 3b.

Result 4: (a) Holding the comparative generosity of the Social Security system constant, $\zeta^2 - \zeta^1$ constant, economies with more generous systems have first higher then lower rates of saving by type 1 agents, lower rates of saving by type 2 agents, with first higher then lower capital overall, first more then less healthy type 1 young and old, less healthy type 2 young and old, less healthy young on average, first more then less healthy old on average, and a population that is first more then less healthy overall. (b) Holding the relative generosity of the Social Security system constant, ζ^2 / ζ^1 constant, economies with more generous systems have first higher then lower rates of saving by type 1 agents, lower rates of saving by type 2 agents, with lower capital overall, less healthy type 1 young, first more then less healthy type 1 old, less healthy type 2 young and old, and less healthy young and old on average.

The effect of increasing the replacement rate schedule, so as to make the system more generous, benefits type 1 agents as they see their lifetime incomes rise. Type two agents who pay more than their share of the increase in generosity see their lifetime incomes fall, and with it their ability to finance consumption and health care throughout their lives. Again, to the extent that the overall healthiness of the population is improved, it is done so to the cost of the poor. These results, in Tables 4a and 4b, point out why the Social Security system is less redistributive than it appears. The poor do get a higher replacement rate on their lower wages, but since they have lower life expectancies, their taxes often subsidize the Social Security benefits of the relatively better off, rather than vice versa.

Result 5: (a) Economies with more generous health care subsidies for the type 1 young, higher σ^1, have higher rates of saving for both types, therefore a higher capital stock, and healthier young and old of both types. (b) Economies with more generous health care subsidies for the type 2 young, higher σ^2, have lower (higher) rates of saving for type 1 (type 2) agents, a lower capital stock, lower (higher) health for the type 1 (type 2) young and old, first lower then higher average health for the young, and first lower then higher average health of the old. (c) Holding the comparative generosity of the health care subsidy system for the young constant, $\sigma^2 - \sigma^1$ constant, economies with more generous systems have higher rates of saving for both types, higher capital stocks, and more healthy young and old of both types. (d) Holding the relative generosity of the health care subsidy system for the young constant, σ^2 / σ^1 constant, economies with more generous systems have higher rates of saving for both types, higher capital stocks, and more healthy young and old of both types.

When the health care of the young is subsidized, they invest more in their health which improves their human capital, which increases their wage (as well as the other type's wage), which increases output. Since type 1 agents outnumber type 2 agents, and since each additional dollar type 1's spend on health care increases own as well as average productivity, these subsidies pay for themselves and benefit all. While such an external effect exists for type 2 agents' health expenditures, it is small. Thus, if type 2 ag

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agents are specifically targeted they will benefit, and society on average may benefit as well, although at the cost of the better off. See Tables 5a - 5d. These results suggest that the current system of not taxing health insurance benefits is, potentially, beneficial to society as a whole, at least at low subsidy rates. Clearly, the smaller the external effect of the benefits, the less beneficial the program.

Result 6: (a) Economies with higher taxes on the saving of the old of both types, higher τ_2^i, have lower rates of saving, lower capital, and lower health for all types at all ages. (b) Holding the taxes on the saving of the old constant, economies with higher lump sum taxes on the old, higher ℓ^i, have lower rates of saving for type 1 agents, higher rates of saving for type 2 agents, and a higher capital stock, first more then less healthy type 1 young, less healthy type 1 old, more healthy type 2 young and old, first more then less healthy young on average, less healthy old on average, and a first more then less healthy population overall.

An increase in the tax on saving reduces the return to saving in all its forms. It also reduces lifetime income, thereby reducing expenditures when both young and old. However, to keep the government's budget balanced, the tax on labor income while young must adjust, and it falls so agents see higher after tax wage income, inducing them to invest more in both health maintenance and capital. The net effect on lifetime healthiness and capital accumulation is, theoretically, ambiguous. The tax on saving represents one measure of the extent to which the old pay for their own programs. This suggests that holding the program constant and increasing the elderly's share of the financing burden may be detrimental to society as a whole in steady-state equilibrium if the old pay for their programs via a tax on their savings. Even if the old's share of the program costs falls because the young's share of the costs rises, there is no reason to expect that healthiness of the young, healthiness of the old, and capital accumulation will increase. This is because the increase in tax reduces agents' income when young, and thereby their expenditures on capital and health maintenance. These reductions are offset all or in part by the increase in income when old, and so the overall effect is again uncertain. Table 6a suggests that the uniform taxation of the returns to saving is never beneficial. However, Table 6b shows that making the old pay a greater percentage of the costs of the program via lump sum taxes can lead to improvements in the health of the population, particularly the health of the poor. This suggests that holding the tax burden on the old constant, but shifting from distortionary to lump sum taxation, could improve the healthiness of the old overall.

Results 1-4 and 6 together suggest that increasing the generosity of programs for the elderly does not necessarily increase the welfare of the old in steady-state equilibrium. Clearly, when the increased taxes fall on the young, the first generation of old benefit, since their benefits rise at no cost to themselves. The current young, by paying for the increased benefits, see their disposable income reduced, reducing their ability to invest in their own health, thus productivity, when young, and to save for their retirement. For them, higher subsidy and replacement rates may translate into lower overall benefits. Even when the increased costs of the program fall on the old, the disincentives to saving are such that steady-state welfare may be reduced unless lump sum taxes are possible.

These results seem at odds with casual empiricism that would suggest that average health, at least measured in terms of life expectancy, has risen since the inception of the social security and Medicare systems. This may indeed be the case, as improvements in medical technology may have more to do with improvements in overall healthiness than the social welfare policies designed for that purpose. However, as Newhouse (1992) suggests, the Medicare system itself may have enabled or furthered improvements in technology that might not have occurred in the absence of the system.

Result 7: (a) Economies with higher medical care costs for the young, higher γ^{i}_{m1}, have lower rates of saving, lower capital, and lower health of all types at all ages. (b) Economies with higher non-medical care costs for the young, higher γ^{i}_{e1}, have lower rates of saving, therefore capital, and less healthy young and old.

A higher price of health care, either medical or non-medical, for the young reduces their total expenditures on health care, which reduces their income when young. This income effect reduces capital accumulation. The reduction of healthiness and capital accumulation when young reduces income when old, and thus health maintenance and healthiness when old. See Tables 7a and 7b. This result does not suggest, however, that the healthiness of the average American has fallen in the post war era during which medical costs have risen faster than the CPI. It may be the case that the quality adjusted price index, the true price index, for medical care has actually fallen. If this is the case the average American should be healthier today. This would also be the case if the price of non-medical health care has fallen faster than the price of medical care has increased.

Result 8: (a) Economies with higher aged dependency ratios, holding population proportions fixed, and holding comparative probabilities of living into old age constant, $p^1 - p^2$ constant, have higher rates of saving for type 1 agents, first higher then lower rates of saving for type 2 agents, higher capital stocks, more healthy type 1 young and old, first more then less healthy type 2 young and old, and higher average health of young and old. (b) Economies with higher aged dependency ratios, holding population proportions fixed, and holding relative probabilities of living into old aged constant, p^1 / p^2 constant, have first higher then lower rates of saving by type 1 agents, higher rates of saving by type 2 agents, first higher then lower capital stocks, first higher then lower healthiness of type 1 young and old, more healthy type 2 young and old, and first higher then lower average health of young and old.

As the economy ages the percentage of old in the population increases, and so the costs of maintaining the programs for the old increase. This increases the taxes on the young and reduces the bequests received by the young. Both effects lead to a reduced incentive to save. However, when agents expect to live longer, they save more, both in terms of human and physical capital, to finance their longer old age. When the latter effect dominates for all agents, agents at all ages and of all types are healthier. However, when the former effect dominates on a type, that type sees a reduction in lifetime healthiness. See Tables 8a and 8b. Clearly, then, population aging in and of itself may not lead to the demise of the Medicare program.

Section IV: Conclusion

This paper has analyzed the steady-state equilibrium effects of a social security/Medicare program for an economy in which there are two types of agents, effectively healthy (rich) and unhealthy (poor), where agents' health is both utility and productivity enhancing. While the quantitative effects of different funding regimes differ, the qualitative effects were strikingly similar: increasing the generosity of the programs for the old does not necessarily lead to increases in steady-state well-being, although the initial old will benefit if the young pay the bills. Further, the funding of increases in generosity may be disproportionately born by the poor, making what was intended to be a progressive policy regressive. Medicare, in the absence of improvements in health care technology, may make us less healthy.

These results do not mean that the system should be dismantled. The do, however, point out that the appropriate level of spending must be valued at the margin. If society as a whole values the elderly, and social welfare is enhanced by the old, whether rich or poor, being ensured a minimum standard of living, then there may indeed be welfare gains to having a Medicare program. However, the welfare gains of the program need to be analyzed in equilibrium, and they need to be analyzed in contrast to the welfare gains available from other possible health care programs, such as those that subsidize the health care of the young. We cannot let transitional, initial generation effects cloud our vision to the stark, unappealing reality that healthier, happier old people today may come at the cost of less healthy, less happy young today and, possibly, less healthy, less happy old tomorrow. Planning in full awareness of the societal costs needs to be the order of the day.

Appendix 1

Baseline Parameter Values

Table 1 Baseline Parameter Values

	Good Health (i=1)	Poor Health (i=2)
Initial health stock when young (initial productivity type)	$\xi^{y1} = 1$	$\xi^{y2} = .5$
Elasticity of healthiness when young with respect to non-medical health expenditures when young	$\nu_1^1 = .2$	$\nu_1^2 = .2$
Elasticity of healthiness when young with respect to medical expenditures when young	$\mu_1^1 = .7$	$\mu_1^2 = .7$
Price of non-medical inputs for the young	$\gamma_{e1}^1 = .3$	$\gamma_{e1}^2 = .3$
Price of medical care for the young	$\gamma_{m1}^1 = 1.5$	$\gamma_{m1}^2 = 1.5$
Government subsidy of health care costs of the young	$\sigma^1 = 0$	$\sigma^2 = 0$
Probability of being alive at retirement	$p^1 = .215$	$p^2 = .165$
Constant shift to health when old	$\xi^{o1} = 1$	$\xi^{o2} = 1$
Elasticity of healthiness when old with respect to non-medical health expenditures when old	$\nu_2^1 = .2$	$\nu_2^2 = .2$
Elasticity of healthiness when old with respect to medical expenditures when old	$\mu_2^1 = .55$	$\mu_2^2 = .55$
Elasticity of healthiness when old with respect to healthiness when young	$\beta^1 = .5$	$\beta^2 = .5$
Price of non-medical inputs for the old	$\gamma_{e2}^1 = .3$	$\gamma_{e2}^2 = .3$
Price of medical care for the old	$\gamma_{m2}^1 = 1.25$	$\gamma_{m2}^2 = 1.25$
Lump sum taxes on the old	$\ell^1 = 0$	$\ell^2 = 0$
Medicare subsidy rate	$\theta^1 = .70$	$\theta^2 = .70$
Social security replacement rate	$\zeta^1 = .42$	$\zeta^2 = .65$
Tax on return on savings of the old	$\tau_2^1 = .10$	$\tau_2^2 = .10$
Number of agents (sum to one)	$N^1 = .7$	$N^2 = .3$
Total Factor Productivity	$A = 5$	

Appendix 2

Simulation Results

Table 1a

The effects of changes in the medicare subsidy rate for high-productivity agents

	1	2	3	4	5	6	7
θ^1	0.05	0.15	0.25	0.35	0.45	0.55	0.65
s^1	0.017955	0.0177065	0.017394	0.0169892	0.0164445	0.0156729	0.0144978
m^{y1}	0.374947	0.367847	0.358985	0.347612	0.332497	0.311459	0.28026
s^2	0.0154082	0.0151203	0.0147619	0.0143037	0.0136975	0.0128589	0.0116257
m^{y2}	0.106113	0.104117	0.10163	0.0984442	0.0942216	0.088364	0.0797186
e^{y1}	0.535638	0.525496	0.512835	0.496588	0.474996	0.444941	0.400371
e^{y2}	0.15159	0.148739	0.145185	0.140635	0.134602	0.126234	0.113884
m^{o1}	0.140351	0.154777	0.172442	0.19453	0.222836	0.260125	0.310486
m^{o2}	0.24317	0.23924	0.234332	0.228032	0.219652	0.207971	0.190592
e^{o1}	0.15159	0.148739	0.145185	0.140635	0.134602	0.126234	0.113884
e^{o2}	0.336201	0.330741	0.323924	0.315176	0.303545	0.287339	0.263244
h^{y1}	0.540455	0.533271	0.524244	0.512562	0.496858	0.474636	0.440832
h^{y2}	0.111683	0.110209	0.108359	0.10597	0.102767	0.0982524	0.0914202
h^{o1}	0.177336	0.18958	0.203859	0.220673	0.240611	0.264172	0.290843
h^{o2}	0.123471	0.121161	0.118285	0.114604	0.10973	0.10298	0.0930357
h^y (av.)	0.411823	0.406352	0.399478	0.390585	0.378631	0.361721	0.336008
h^o (av.)	0.164004	0.172646	0.182679	0.194421	0.208218	0.224277	0.241885
$h^{(all)}$ (av.)	0.37052	0.367401	0.363345	0.357891	0.350229	0.338814	0.320321

Table

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Table 1b

The effects of changes in the medicare subsidy rate for low-productivity agents

	1	2	3	4	5	6	7
θ^2	0.05	0.15	0.25	0.35	0.45	0.55	0.65
s^1	0.0143493	0.0143104	0.0142613	0.0141973	0.0141105	0.0139858	0.0137917
m^{y1}	0.276387	0.275377	0.274103	0.272444	0.270198	0.266983	0.262001
s^2	0.0114735	0.0114338	0.0113838	0.0113187	0.0112305	0.0111045	0.0109094
m^{y2}	0.0786487	0.0783698	0.0780179	0.0775601	0.0769401	0.0760533	0.0746801
e^{y1}	0.394839	0.393396	0.391575	0.389206	0.385997	0.381404	0.374287
e^{y2}	0.112355	0.111957	0.111454	0.1108	0.109914	0.108648	0.106686
m^{o1}	0.358697	0.357772	0.356603	0.35508	0.353011	0.350042	0.345419
m^{o2}	0.0595036	0.0663048	0.0748604	0.0859494	0.100891	0.122111	0.154608
e^{o1}	0.112355	0.111957	0.111454	0.1108	0.109914	0.108648	0.106686
e^{o2}	0.0821828	0.0915753	0.10339	0.118704	0.139336	0.168638	0.213506
h^{y1}	0.436559	0.435442	0.43403	0.43219	0.429692	0.426107	0.420526
h^{y2}	0.0905596	0.0903347	0.0900505	0.0896803	0.089178	0.0884572	0.0873361
h^{o1}	0.322537	0.321505	0.320202	0.318505	0.316205	0.312907	0.307788
h^{o2}	0.0386743	0.0418922	0.0458119	0.0507078	0.0570244	0.065535	0.0777242
h^{y} (av.)	0.332759	0.33191	0.330836	0.329437	0.327538	0.324812	0.320569
h^{o} (av.)	0.252281	0.252301	0.25229	0.252225	0.252057	0.251683	0.250847
$h^{(all)}$ (av.)	0.319346	0.318641	0.317745	0.316569	0.314958	0.312624	0.308949

Table 2a

The effects of changes in the overall medicare subsidy rate, holding the difference in low- and high-productivity rates constant

	1	2	3	4	5	6
θ^1	0.05	0.15	0.25	0.35	0.45	0.55
θ^2	0.2	0.3	0.4	0.5	0.6	0.7
s^1	0.0167819	0.0165443	0.0162455	0.0158587	0.0153385	0.0146022
m^{y1}	0.341836	0.33525	0.32703	0.316486	0.302477	0.282989
s^2	0.0140717	0.0138077	0.013479	0.0130587	0.0125026	0.0117331
m^{y2}	0.0968291	0.0949898	0.0926973	0.0897616	0.0858703	0.080473
e^{y1}	0.488337	0.478929	0.467186	0.452123	0.43211	0.40427
e^{y2}	0.138327	0.1357	0.132425	0.128231	0.122672	0.114961
m^{o1}	0.131544	0.145025	0.161521	0.182126	0.208492	0.243145
m^{o2}	0.449661	0.442359	0.433239	0.421529	0.405952	0.384231
e^{o1}	0.138327	0.1357	0.132425	0.128231	0.122672	0.114961
e^{o2}	0.621465	0.611329	0.598673	0.582427	0.560823	0.530711
h^{y1}	0.506585	0.499734	0.491125	0.479986	0.465013	0.443833
h^{y2}	0.10475	0.103353	0.101601	0.0993376	0.0963032	0.0920249
h^{o1}	0.163604	0.174844	0.187935	0.203323	0.221522	0.242931
h^{o2}	0.189604	0.186034	0.181588	0.175898	0.168363	0.157925
h^y (av.)	0.386035	0.38082	0.374268	0.365791	0.3544	0.33829
h^o (av.)	0.170039	0.177613	0.186364	0.196535	0.208365	0.221892
$h^{(all)}$ (av.)	0.350035	0.346952	0.34295	0.337582	0.330061	0.318891

Table 2b

The effects of changes in the overall medicare subsidy rate, holding the ratio between low- and high-productivity rates constant

	1	2	3	4	5	6
θ^1	0.05	0.15	0.25	0.35	0.45	0.55
θ^2	0.0625	0.1875	0.3125	0.4375	0.5625	0.6875
s^1	0.0187875	0.0184533	0.0180184	0.0174228	0.0165323	0.0149017
m^{y1}	0.399058	0.389317	0.376764	0.359798	0.334919	0.290868
s^2	0.0163914	0.0159931	0.015482	0.0147947	0.0137944	0.0120436
m^{y2}	0.112912	0.110161	0.106624	0.101858	0.0948973	0.0826528
e^{y1}	0.570082	0.556167	0.538235	0.513997	0.478456	0.415525
e^{y2}	0.161304	0.157373	0.15232	0.145511	0.135568	0.118075
m^{o1}	0.146604	0.161045	0.17838	0.199287	0.223974	0.247896
m^{o2}	0.0831941	0.0972092	0.117204	0.148284	0.203996	0.336875
e^{o1}	0.161304	0.157373	0.15232	0.145511	0.135568	0.118075
e^{o2}	0.115053	0.134421	0.162047	0.204979	0.281917	0.465338
h^{y1}	0.564554	0.554872	0.542287	0.525075	0.499388	0.452446
h^{y2}	0.116646	0.114649	0.11206	0.108529	0.103283	0.0937628
h^{o1}	0.187222	0.19918	0.212629	0.227404	0.24214	0.248838
h^{o2}	0.0564502	0.0628952	0.0715439	0.0839878	0.104071	0.144436
h^{y} (av.)	0.430181	0.422805	0.413219	0.400111	0.380557	0.344841
h^{o} (av.)	0.154856	0.16545	0.17771	0.191908	0.207968	0.222999
$h^{(all)}$ (av.)	0.384294	0.379912	0.373967	0.365411	0.351792	0.324534

Table 2c(i)

The effects of changes in the overall medicare subsidy rate, holding the ratio between low- and high-productivity rates constant

	1	2	3	4	5
θ^1, θ^2	0.15	0.3	0.45	0.6	0.75
s^1	0.0184957	0.0178878	0.0169692	0.0154246	0.0123155
m^{y1}	0.390549	0.373021	0.347054	0.304782	0.225027
s^2	0.0160434	0.01533	0.0142813	0.0125939	0.00946975
m^{y2}	0.110509	0.105571	0.0982883	0.0865098	0.0645191
e^{y1}	0.557927	0.532887	0.495792	0.435403	0.321467
e^{y2}	0.15787	0.150816	0.140412	0.123585	0.0921701
m^{o1}	0.161401	0.189791	0.22964	0.288212	0.372235
m^{o2}	0.0888726	0.103759	0.124212	0.153194	0.19145
e^{o1}	0.15787	0.150816	0.140412	0.123585	0.0921701
e^{o2}	0.122894	0.143451	0.171681	0.211642	0.264296
h^{y1}	0.5561	0.53851	0.511987	0.467491	0.378046
h^{y2}	0.114902	0.111284	0.105853	0.0968047	0.0788373
h^{o1}	0.199729	0.221982	0.249778	0.283156	0.308824
h^{o2}	0.0588699	0.0650685	0.072625	0.0812739	0.086679
h^{y} (av.)	0.423741	0.410342	0.390146	0.356285	0.288283
h^{o} (av.)	0.164866	0.183146	0.205933	0.23319	0.253843
$h^{(all)}$ (av.)	0.380595	0.372476	0.359444	0.335769	0.282543

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Table 2c(ii)

The effects of changes in the overall medicare subsidy rate, holding the rates for both groups equal to one-another (detail)

	1	2	3	4
θ^1, θ^2	0.75	0.76	0.77	0.78
s^1	0.0123155	0.0119948	0.0116521	0.0112849
m^{y1}	0.225027	0.217215	0.20895	0.200196
s^2	0.00946975	0.00916732	0.00884764	0.00850971
m^{y2}	0.0645191	0.0623793	0.060116	0.0577216
e^{y1}	0.321467	0.310307	0.2985	0.285995
e^{y2}	0.0921701	0.0891132	0.08588	0.0824595
m^{o1}	0.372235	0.378164	0.383909	0.389365
m^{o2}	0.19145	0.193886	0.196174	0.198268
e^{o1}	0.0921701	0.0891132	0.08588	0.0824595
e^{o2}	0.264296	0.267642	0.270784	0.273656
h^{y1}	0.378046	0.368811	0.35893	0.348337
h^{y2}	0.0788373	0.0769978	0.0750315	0.0729269
h^{o1}	0.308824	0.308703	0.308043	0.306735
h^{o2}	0.086679	0.086477	0.0861191	0.0855803
h^{y} (av.)	0.288283	0.281267	0.273761	0.265714
h^{o} (av.)	0.253843	0.253702	0.253117	0.251999
$h^{(all)}$ (av.)	0.282543	0.276673	0.27032	0.263428

Table

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Table 3a

The effects of changes in the social security replacement rate for high-productivity agents

	1	2	3	4	5	6
ζ^1	0.2	0.3	0.4	0.5	0.6	0.7
s^1	0.00103654	0.0106217	0.0137236	0.0122033	0.00960793	0.00728646
m^{y1}	0.275296	0.291291	0.266725	0.220711	0.174958	0.136585
s^2	0.0566425	0.0300142	0.012854	0.0054167	0.00249875	0.00126441
m^{y2}	0.248534	0.153068	0.0832854	0.0463086	0.0278399	0.0178485
e^{y1}	0.393281	0.41613	0.381035	0.315302	0.24994	0.195122
e^{y2}	0.355048	0.218669	0.118979	0.0661551	0.0397713	0.0254979
m^{o1}	0.112768	0.262177	0.336628	0.342907	0.319768	0.287988
m^{o2}	0.689071	0.403793	0.204538	0.106477	0.0612581	0.0384103
e^{o1}	0.355048	0.218669	0.118979	0.0661551	0.0397713	0.0254979
e^{o2}	0.975202	0.5658	0.283068	0.146125	0.083999	0.0529979
h^{y1}	0.435352	0.452907	0.425818	0.372956	0.316982	0.26654
h^{y2}	0.202638	0.144335	0.0942646	0.0625048	0.0437742	0.032068
h^{o1}	0.131144	0.258282	0.30362	0.288918	0.253495	0.215629
h^{o2}	0.364942	0.205876	0.0996501	0.049647	0.0274412	0.0165704
h^y (av.)	0.365538	0.360336	0.326352	0.279821	0.23502	0.196199
h^o (av.)	0.189009	0.245311	0.253137	0.229699	0.197547	0.166362
$h^{(all)}$ (av.)	0.336116	0.341165	0.31415	0.271467	0.228774	0.191226

Table 3b

The effects of changes in the social security replacement rate for low-productivity agents

	1	2	3	4	5
ζ^2	0.2	0.3	0.4	0.5	0.6
s^1	0.0214046	0.0202611	0.0186068	0.0166548	0.014632
m^{y1}	0.314005	0.306911	0.295884	0.281937	0.266364
s^2	0.000743595	0.00264203	0.00501802	0.00750286	0.00977335
m^{y2}	0.0234231	0.0346046	0.046828	0.0586907	0.0691438
e^{y1}	0.448578	0.438445	0.422691	0.402767	0.380519
e^{y2}	0.0334616	0.0494352	0.0668972	0.0838439	0.0987769
m^{o1}	0.446077	0.431694	0.410283	0.384188	0.356098
m^{o2}	0.0164076	0.0443387	0.0802536	0.120001	0.159534
e^{o1}	0.0334616	0.0494352	0.0668972	0.0838439	0.0987769
e^{o2}	0.0212054	0.0600596	0.110079	0.165368	0.220228
h^{y1}	0.477349	0.469775	0.457894	0.442677	0.425415
h^{y2}	0.0387884	0.0509735	0.0629948	0.0737818	0.0827518
h^{o1}	0.397642	0.384832	0.365631	0.342134	0.316765
h^{o2}	0.0095042	0.0231803	0.0403133	0.0590495	0.0774521
h^{y} (av.)	0.345781	0.344134	0.339424	0.332008	0.322616
h^{o} (av.)	0.301578	0.295324	0.285115	0.27207	0.257535
$h^{(all)}$ (av.)	0.338413	0.335999	0.330373	0.322018	0.311769

Table 4a

The effects of changes in the overall social security replacement rate, holding the difference in low- and high-productivity rates constant

	1	2	3	4	5	6
ζ^1	0.2	0.3	0.4	0.5	0.6	0.7
ζ^2	0.43	0.53	0.63	0.73	0.83	0.93
s^1	0.00103654	0.0106217	0.0137236	0.0122033	0.00960793	0.00728646
m^{y1}	0.275296	0.291291	0.266725	0.220711	0.174958	0.136585
s^2	0.0566425	0.0300142	0.012854	0.0054167	0.00249875	0.00126441
m^{y2}	0.248534	0.153068	0.0832854	0.0463086	0.0278399	0.0178485
e^{y1}	0.393281	0.41613	0.381035	0.315302	0.24994	0.195122
e^{y2}	0.355048	0.218669	0.118979	0.0661551	0.0397713	0.0254979
m^{o1}	0.112768	0.262177	0.336628	0.342907	0.319768	0.287988
m^{o2}	0.689071	0.403793	0.204538	0.106477	0.0612581	0.0384103
e^{o1}	0.355048	0.218669	0.118979	0.0661551	0.0397713	0.0254979
e^{o2}	0.975202	0.5658	0.283068	0.146125	0.083999	0.0529979
h^{y1}	0.435352	0.452907	0.425818	0.372956	0.316982	0.26654
h^{y2}	0.202638	0.144335	0.0942646	0.0625048	0.0437742	0.032068
h^{o1}	0.131144	0.258282	0.30362	0.288918	0.253495	0.215629
h^{o2}	0.364942	0.205876	0.0996501	0.049647	0.0274412	0.0165704
h^y (av.)	0.365538	0.360336	0.326352	0.279821	0.23502	0.196199
h^o (av.)	0.189009	0.245311	0.253137	0.229699	0.197547	0.166362
$h^{(all)}$ (av.)	0.336116	0.341165	0.31415	0.271467	0.228774	0.191226

Table

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Table 4b

The effects of changes in the overall social security replacement rate, holding the ratio between low- and high-productivity rates constant

	1	2	3	4
ς^1	0.25	0.35	0.45	0.55
ς^2	0.386905	0.541667	0.696429	0.85119
s^1	0.0145205	0.0160724	0.012522	0.0091789
m^{y1}	0.369305	0.308757	0.238324	0.181154
s^2	0.0414088	0.0173114	0.0090122	0.0053689
m^{y2}	0.189761	0.102515	0.0650436	0.0449875
e^{y1}	0.527578	0.441082	0.340463	0.258792
e^{y2}	0.271087	0.14645	0.0929195	0.0642679
m^{o1}	0.290724	0.350052	0.334214	0.301627
m^{o2}	0.444254	0.239318	0.160887	0.121388
e^{o1}	0.271087	0.14645	0.0929195	0.0642679
e^{o2}	0.635898	0.333859	0.221643	0.167078
h^{y1}	0.534749	0.47175	0.393549	0.324799
h^{y2}	0.167762	0.109019	0.0792855	0.0612513
h^{o1}	0.302812	0.32868	0.290734	0.245344
h^{o2}	0.239454	0.120754	0.0762631	0.0542547
h^{y} (av.)	0.424653	0.362931	0.29927	0.245734
h^{o} (av.)	0.287131	0.277218	0.237652	0.198049
$h^{(all)}$ (av.)	0.401733	0.348646	0.289	0.237787

Table

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Table 5a

The effects of changes in the health care subsidy rate for young high-productivity agents

	1	2	3	4	5	6
σ^1	0.	0.05	0.1	0.15	0.2	0.25
s^1	0.0136477	0.0152312	0.0170788	0.0192507	0.0218249	0.024904
m^{y1}	0.258321	0.29911	0.348933	0.410443	0.487294	0.584611
s^2	0.0107655	0.0111397	0.011531	0.0119396	0.0123659	0.012809
m^{y2}	0.0736662	0.0752715	0.0769349	0.0786569	0.0804373	0.082275
e^{y1}	0.369029	0.405935	0.448628	0.498395	0.556907	0.626369
e^{y2}	0.105237	0.107531	0.109907	0.112367	0.11491	0.117536
m^{o1}	0.341985	0.377651	0.419012	0.467343	0.524302	0.592072
m^{o2}	0.178312	0.182962	0.187799	0.192824	0.198039	0.203441
e^{o1}	0.105237	0.107531	0.109907	0.112367	0.11491	0.117536
e^{o2}	0.246231	0.252769	0.259575	0.26665	0.273998	0.281616
h^{y1}	0.416382	0.456675	0.503209	0.557367	0.620943	0.696305
h^{y2}	0.0865044	0.0878196	0.0891737	0.0905662	0.0919964	0.093462
h^{o1}	0.303997	0.342968	0.389216	0.44459	0.511554	0.593443
h^{o2}	0.0860867	0.0884381	0.0908869	0.093435	0.0960832	0.098830
h^{y} (av.)	0.317419	0.346018	0.378998	0.417326	0.462259	0.515452
h^{o} (av.)	0.250064	0.279972	0.315379	0.357679	0.408725	0.471026
$h^{(all)}$ (av.)	0.306193	0.33501	0.368395	0.407385	0.453337	0.508048

Table 5b

The effects of changes in the health care subsidy rate for young low-productivity agents

	1	2	3	4	5	6
σ^2	0.05	0.15	0.25	0.35	0.45	0.55
s^1	0.0133049	0.0125405	0.0116544	0.0106241	0.00942472	0.00803296
m^{y1}	0.255681	0.249667	0.242455	0.2337	0.222926	0.209462
s^2	0.0113167	0.0125511	0.0139947	0.0156998	0.0177433	0.0202561
m^{y2}	0.0825975	0.10558	0.138596	0.188233	0.267521	0.405429
e^{y1}	0.365259	0.356667	0.346364	0.333857	0.318466	0.299232
e^{y2}	0.112097	0.128204	0.148495	0.174788	0.210195	0.260633
m^{o1}	0.337126	0.326155	0.313184	0.297716	0.279105	0.256516
m^{o2}	0.189108	0.214125	0.245013	0.284095	0.335272	0.405845
e^{o1}	0.112097	0.128204	0.148495	0.174788	0.210195	0.260633
e^{o2}	0.261016	0.295235	0.337414	0.390694	0.460366	0.556382
h^{y1}	0.413399	0.406568	0.39831	0.388187	0.375572	0.359546
h^{y2}	0.0927624	0.107731	0.127112	0.153045	0.18931	0.243295
h^{o1}	0.299663	0.289877	0.278302	0.264493	0.247869	0.227676
h^{o2}	0.0931557	0.110172	0.132367	0.162249	0.204257	0.26714
h^{y} (av.)	0.317208	0.316917	0.316951	0.317645	0.319693	0.324671
h^{o} (av.)	0.248553	0.2454	0.242183	0.239188	0.237075	0.237443
$h^{(all)}$ (av.)	0.305766	0.304997	0.30449	0.304569	0.305924	0.310133

Table 5c

The effects of changes in the overall health care subsidy rate for young agents, holding the difference in low- and high-productivity rates constant

	1	2	3	4	5	6
σ^1	0.05	0.1	0.15	0.2	0.25	0.3
σ^2	0.2	0.25	0.3	0.35	0.4	0.45
s^1	0.0140473	0.0158117	0.0178934	0.0203699	0.0233438	0.026953
m^{y1}	0.289498	0.338218	0.398451	0.473817	0.569394	0.692466
s^2	0.0130444	0.0135651	0.0141146	0.0146942	0.0153047	0.015947
m^{y2}	0.108146	0.110828	0.113628	0.11655	0.119597	0.122768
e^{y1}	0.392891	0.434852	0.483834	0.541505	0.610065	0.692466
e^{y2}	0.13132	0.134576	0.137977	0.141525	0.145225	0.149076
m^{o1}	0.360852	0.40117	0.448376	0.504123	0.570588	0.650696
m^{o2}	0.220367	0.226916	0.233784	0.240982	0.248519	0.2564
e^{o1}	0.13132	0.134576	0.137977	0.141525	0.145225	0.149076
e^{o2}	0.30399	0.313183	0.322833	0.332954	0.343561	0.35466
h^{y1}	0.446352	0.492342	0.545917	0.608871	0.683568	0.773177
h^{y2}	0.109558	0.111452	0.113416	0.11545	0.117554	0.119728
h^{o1}	0.327662	0.372591	0.426494	0.491812	0.571853	0.671189
h^{o2}	0.113533	0.117066	0.120776	0.124671	0.128756	0.133035
h^{y} (av.)	0.345314	0.378075	0.416167	0.460845	0.513764	0.577142
h^{o} (av.)	0.274665	0.309348	0.350829	0.400944	0.462187	0.537996
$h^{(all)}$ (av.)	0.333539	0.36662	0.405277	0.450861	0.505167	0.570618

Table 5d

The effects of changes in the overall subsidy rate for health care when young, holding the ratio between low- and high-productivity rates constant

	1	2	3	4	5
σ^1	0.05	0.1	0.15	0.2	0.25
σ^2	0.1	0.2	0.3	0.4	0.5
s^1	0.014472	0.015318	0.016151	0.0169047	0.0174554
m^{y1}	0.292992	0.333925	0.382357	0.439599	0.506714
s^2	0.0123595	0.0143614	0.0169276	0.0202993	0.0248658
m^{y2}	0.0952902	0.126738	0.174519	0.251291	0.38415
e^{y1}	0.397632	0.429332	0.464291	0.502399	0.542908
e^{y2}	0.122516	0.144843	0.174519	0.215392	0.274393
m^{o1}	0.366924	0.394106	0.423398	0.454272	0.485361
m^{o2}	0.206636	0.242915	0.29061	0.355391	0.447213
e^{o1}	0.122516	0.144843	0.174519	0.215392	0.274393
e^{o2}	0.285201	0.335074	0.400569	0.489418	0.615167
h^{y1}	0.450116	0.487959	0.530387	0.577748	0.62998
h^{y2}	0.101422	0.120949	0.147319	0.184376	0.239274
h^{o1}	0.333195	0.366007	0.402652	0.443008	0.486133
h^{o2}	0.104102	0.128331	0.161989	0.210706	0.285121
h^{y} (av.)	0.345508	0.377856	0.415467	0.459736	0.512768
h^{o} (av.)	0.276494	0.307182	0.343088	0.385513	0.436383
$h^{(all)}$ (av.)	0.334005	0.366077	0.403404	0.447366	0.500037

Table 6a

The effects of changes in the income tax rate for old agents

	1	2	3	4	5	6
τ_2^1, τ_2^2	0.	0.05	0.1	0.15	0.2	0.25
s^1	0.0165007	0.0150784	0.0136477	0.0122243	0.0108241	0.009
m^{y1}	0.267774	0.263842	0.258321	0.251199	0.242482	0.232
s^2	0.0135885	0.0121433	0.0107655	0.00946201	0.0082382	0.007
m^{y2}	0.0842531	0.079005	0.0736662	0.0682698	0.062848	0.057
e^{y1}	0.382535	0.376917	0.369029	0.358855	0.346402	0.331
e^{y2}	0.120362	0.112864	0.105237	0.0975283	0.0897829	0.082
m^{o1}	0.385661	0.364374	0.341985	0.318686	0.294681	0.270
m^{o2}	0.216422	0.197075	0.178312	0.160223	0.142889	0.126
e^{o1}	0.492083	0.468529	0.443706	0.417815	0.391066	0.363
e^{o2}	0.296137	0.270801	0.246231	0.222542	0.199832	0.178
h^{y1}	0.426991	0.422591	0.416382	0.408312	0.398341	0.386
h^{y2}	0.0950299	0.0908466	0.0865044	0.0820183	0.0774024	0.072
h^{o1}	0.335761	0.320596	0.303997	0.286117	0.267129	0.247
h^{o2}	0.104146	0.0950019	0.0860867	0.0774527	0.0691448	0.061
h^{y} (av.)	0.327403	0.323068	0.317419	0.310424	0.30206	0.292
h^{o} (av.)	0.278436	0.264762	0.250064	0.234472	0.218128	0.201
$h^{(all)}$ (av.)	0.319242	0.31335	0.306193	0.297766	0.288071	0.277

Table 6b

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Table 6b

The effects of changes in the lump sum tax paid by old agents

	1	2	3	4	5	6
l^1,l^2	0	0.01	0.02	0.03	0.04	0.05
	0.0136477	0.0135925	0.0134134	0.0130997	0.0126404	0.0120237
[illegible]	0.258321	0.262315	0.265534	0.267933	0.269466	0.270079
s^2	0.0107655	0.0124363	0.0143084	0.0163993	0.0187265	0.0213076
m^{y2}	0.0736662	0.0810624	0.0890708	0.0977338	0.107093	0.117191
e^{y1}	0.369029	0.374736	0.379334	0.382762	0.384952	0.385827
e^{y2}	0.105237	0.115803	0.127244	0.13962	0.15299	0.167415
m^{o1}	0.341985	0.334288	0.325002	0.314027	0.301253	0.286561
m^{o2}	0.178312	0.199123	0.221956	0.246962	0.274294	0.304104
e^{o1}	0.443706	0.429428	0.412978	0.394218	0.372997	0.349152
e^{o2}	0.246231	0.27549	0.307678	0.343022	0.38175	0.424086
h^{y1}	0.416382	0.420879	0.424487	0.427168	0.428878	0.42956
h^{y2}	0.0865044	0.0924962	0.0988019	0.105434	0.112405	0.119722
h^{o1}	0.303997	0.299863	0.294208	0.286932	0.27792	0.267045
h^{o2}	0.0860867	0.0967387	0.108505	0.121479	0.135758	0.15144
h^{y} (av.)	0.317419	0.322364	0.326781	0.330648	0.333936	0.336609
h^{o} (av.)	0.250064	0.24959	0.248247	0.245982	0.242735	0.238433
$h^{(all)}$ (av.)	0.306193	0.310235	0.313692	0.316537	0.318736	0.320246

Table 7a

The effects of changes in the price of health care for young agents

	1	2	3	4	5	6
$\gamma^1_{m1}, \gamma^2_{m1}$	1	1.1	1.2	1.3	1.4	1.5
s^1	0.0268252	0.0228853	0.0197959	0.0173236	0.0153108	0.013647
m^{y1}	0.761615	0.590684	0.468366	0.378344	0.3105	0.258321
s^2	0.0211602	0.0180523	0.0156153	0.0136651	0.0120774	0.010765
m^{y2}	0.217193	0.168447	0.133566	0.107894	0.0885462	0.073666
e^{y1}	0.725348	0.618812	0.535276	0.468426	0.413999	0.369029
e^{y2}	0.20685	0.176469	0.152647	0.133583	0.118062	0.105237
m^{o1}	0.672191	0.573462	0.496048	0.434097	0.38366	0.341985
m^{o2}	0.350481	0.299004	0.25864	0.226339	0.200041	0.178312
e^{o1}	0.87213	0.744035	0.643595	0.563217	0.497777	0.443706
e^{o2}	0.48398	0.412895	0.357157	0.312552	0.276236	0.246231
h^{y1}	0.818422	0.698215	0.60396	0.528532	0.467122	0.416382
h^{y2}	0.170029	0.145056	0.125474	0.109804	0.0970458	0.086504
h^{o1}	0.707499	0.580084	0.48391	0.409585	0.350988	0.303997
h^{o2}	0.200352	0.16427	0.137035	0.115987	0.0993939	0.086086
h^y (av.)	0.623904	0.532267	0.460414	0.402914	0.356099	0.317419
h^o (av.)	0.58198	0.47717	0.398059	0.336919	0.288719	0.250064
$h^{(all)}$ (av.)	0.616917	0.523085	0.450022	0.391915	0.344869	0.306193

Table 7b

The effects of changes in the price of exercise for young agents

	1	2	3	4	5
γ^2_{ml}	1.	1.1	1.2	1.3	1.4
s^1	0.0108069	0.0114934	0.012114	0.0126758	0.0131851
m^{y1}	0.235284	0.241113	0.24623	0.250745	0.25475
s^2	0.0153947	0.0142591	0.0132439	0.012332	0.0115097
m^{y2}	0.178374	0.14547	0.120517	0.101177	0.0859087
e^{y1}	0.33612	0.344448	0.351756	0.358207	0.363929
e^{y2}	0.16988	0.152398	0.137734	0.125266	0.114545
m^{o1}	0.300493	0.310795	0.319947	0.328111	0.335419
m^{o2}	0.276875	0.250878	0.228716	0.209596	0.19294
e^{o1}	0.389538	0.402936	0.414868	0.425533	0.435099
e^{o2}	0.380857	0.345415	0.315168	0.289044	0.266262
h^{y1}	0.390028	0.396767	0.402641	0.407796	0.412345
h^{y2}	0.148137	0.130904	0.116762	0.104973	0.0950132
h^{o1}	0.266972	0.276169	0.284338	0.291621	0.298141
h^{o2}	0.156581	0.136725	0.120496	0.107027	0.0957054
h^y (av.)	0.31746	0.317008	0.316878	0.316949	0.317146
h^o (av.)	0.239651	0.241657	0.243787	0.245934	0.248038
$h^{(all)}$ (av.)	0.304492	0.304449	0.304696	0.305113	0.305628

Table 8a

The effects of changes in the overall age-dependency rate, holding the difference in low- and high-productivity rates constant

	1	2	3	4
p^1	0.18	0.2	0.22	0.24
p^2	0.08	0.1	0.12	0.14
s^1	0.0012764	0.00279838	0.00483014	0.00716348
m^{y1}	0.127283	0.158119	0.183296	0.201879
s^2	0.0118309	0.0152635	0.0175157	0.0184839
m^{y2}	0.105469	0.113806	0.114465	0.109528
e^{y1}	0.181834	0.225884	0.261852	0.288399
e^{y2}	0.15067	0.16258	0.163522	0.156468
m^{o1}	0.119705	0.162799	0.204492	0.241852
m^{o2}	0.266224	0.291979	0.297911	0.288669
e^{o1}	0.15067	0.16258	0.163522	0.156468
e^{o2}	0.394256	0.42451	0.426719	0.408169
h^{y1}	0.2537	0.295304	0.327483	0.350384
h^{y2}	0.111208	0.117291	0.117766	0.114187
h^{o1}	0.109687	0.147593	0.183353	0.214331
h^{o2}	0.133693	0.146607	0.148692	0.142625
h^y (av.)	0.210953	0.2419	0.264568	0.279525
h^o (av.)	0.113528	0.147419	0.176785	0.19999
$h^{(all)}$ (av.)	0.198245	0.228172	0.250552	0.265722

Table 8b

The effects of changes in the overall age-dependency rate, holding the ratio between low- and high-productivity rates constant

	1	2	3	4	5
p^1	0.215	0.215	0.215	0.215	0.215
p^2	0.1	0.15	0.2	0.25	0.3
s^1	0.00226528	0.0110061	0.0172942	0.0191044	0.0197055
m^{y1}	0.14895	0.23953	0.281506	0.291543	0.294038
s^2	0.0158989	0.0135669	0.00604969	0.00325423	0.00214037
m^{y2}	0.116238	0.088197	0.0500831	0.0354003	0.0290246
e^{y1}	0.212785	0.342186	0.402151	0.416491	0.420055
e^{y2}	0.166054	0.125996	0.0715473	0.0505719	0.0414637
m^{o1}	0.150267	0.304888	0.390073	0.412614	0.419578
m^{o2}	0.301431	0.220503	0.111415	0.0717036	0.0552992
e^{o1}	0.166054	0.125996	0.0715473	0.0505719	0.0414637
e^{o2}	0.438389	0.3084	0.149476	0.0931268	0.070188
h^{y1}	0.28321	0.394941	0.442203	0.453182	0.455893
h^{y2}	0.11904	0.0981224	0.0660289	0.0517912	0.0450699
h^{o1}	0.135932	0.271575	0.345941	0.365387	0.371152
h^{o2}	0.151277	0.107792	0.0525535	0.0332269	0.0253917
h^y (av.)	0.233959	0.305896	0.329351	0.332765	0.332646
h^o (av.)	0.138482	0.233875	0.262315	0.254912	0.241761
$h^{(all)}$ (av.)	0.21936	0.294118	0.317693	0.318439	0.315026

Chapter 4. Empirical Support for the Alienation Hypothesis in U.S. Presidential Elections

Section I: Introduction

A great deal of academic debate within political economy in the past four decades has centered on decisions of participation and abstention by rational voters. This paper seeks to examine the empirical evidence for the existence of one factor in the participation decision, that of alienation.

Alienation is the process by which voters who can discriminate between the candidates on offer, but who feel that neither of the candidates is of high enough quality will tend to abstain from the election. As such, alienation should also be separated from abstention due to indifference, wherein the agent feels that the candidates (whether their quality is high or low) are indistinguishable from one another, and thus are not worth voting for.

Alienation is a function of the quality of the candidates on offer, and while it is related to the institutional factors which propel conventional abstention, such as opportunity costs and lack of information, it is distinguished from these factors by dint of being the only form of abstention which candidate strategy (in terms of policy position) can directly induce or diminish.

If the alienation hypothesis should be confirmed, there are considerable theoretical and practical implications for candidate strategies and electoral outcomes. While this paper concentrates on empirical support for alienation, it is worth noting that theoretical treatments of the subject[19] have yielded equilibrium non-convergence of

19 For example Anderson and Glomm, (1992).

policy platforms in vote-maximizing games, as well as providing evidence for polarized campaign strategies in policy models.

The key implication of alienation is the introduction of a "loss of support" into the candidate's strategic model. Without alienation, as a candidate converges on the location of his rival, he can only gain. Every step he takes towards his opponent will "convert" some of his opponent's supporters, or at least make them indifferent.

However, when alienation is a possibility, the candidate is aware that any move will not only increase his support among the voters he is moving towards, but will also diminish the participation rate of those he moves away from. Essentially, it means that the tails of the voter distribution (outside of the pair of candidates) are no longer "guaranteed supporters", but rather are "potential supporters" whose support must be wooed every bit as assiduously as those in the traditional battleground between the candidates.

As a consequence, candidates are less likely to be willing to converge, unless the reward to convergence, in terms of additional votes, is greater than the losses incurred in the tails. When it is considered that party activists and donors are generally *more extreme* than their parties' candidates, the costs of convergence may easily outweigh the benefits, even when the distribution of voters is centrist.

However, there is, as yet, no clear evidence that alienation is a significant factor in US politics. Firstly, participation studies in the literature of voting have concentrated on the environmental and demographic factors which influence turnout and individual behavior, rather than the role of the candidates' strategic decisions.[20]

Secondly, the whole question of alienation is subject to the rational voting paradox. If theory implies that candidate strategies should be essentially identical, and that the motivation to participate on strategic grounds is effectively zero, how much support can there be for a model that differentiates agents in terms of their participation responses to strategic alternatives?

To deal with these problems, I intend to present a simple model of participation which is not subject to the rational voting paradox, but which instead describes rational participation *and* abstention. The paradox itself is described in Section II, while the model of voter behavior is outlined in Section III.

Section IV then contains the results of a series of econometric analyses of voting behavior from the 1980-1988 Presidential elections, and finds that not only is alienation apparent in voting tendencies, but that this behavior is not accounted for by conventional demographic or institutional factors. Section V offers some indications as to the nature of the voter's strategic decision-making process.

Section II: The rational voting paradox, alienation, and participation

The key question here is the strictly limited one of whether alienation is a significant factor in the behavior of voters in US presidential elections. Alienation has, in

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[20] The most notable attempts at candidate placement implications have naturally (given the post-Downsian emphasis on convergence and the lack of rational participation) centered on the effects of third

the past, been disregarded on the basis that it constitutes a problem only when dealing with rational voters, and as, under the "rational voting paradox" no such voters exist, alienation is no more than a theoretical irrelevancy.

Voters whose motivations are drawn from non-strategic, irrational motives may be alienated, but not on the grounds of rational analysis of candidate placement. As such, abstention through irrational alienation lies beyond the scope of this paper.

Any reasonable analysis of the question of alienation must also, at least implicitly, act as a partial answer to the rational voting paradox. This paradox is a direct consequence of the conclusions of Downs' seminal 1957 work. Downs found that, within a simple model of rational voting behavior and rational candidate strategy, (a) there would be no difference between the policy positions of the two candidates and (b) agents would be aware that their impact on the election was effectively zero, while participation would in some sense be costly.

As such, participation resulting from candidate placement should be negligible, and candidate differentiation should be minimal. As a consequence, neither the candidates nor the voters should possess any significant strategic motive.

This does not necessarily mean that there are no rational grounds for participation, and hence that turnout would be zero. Rather, it implies that there are no rational *strategic* reasons to participate, and there are no rational *strategic* motives for candidates to separate themselves in the case of simple two-party elections.

While in the intervening years many authors have demonstrated limiting cases within which these conclusions are invalid, these have relied upon highly specific

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candidates. See Alvarez and Nagler (1995) or Whitten and Palmer (1996), for example.

behavioral or environmental conditions. When politicians are motivated by factors other than victory, or when there are n>2 participants, etc., the Downsian result may be overturned. However, these form exceptions to a much more general rule, that of non-participation and candidate convergence.[21]

Thus, this paper employs a simple model of the US election, as a single-shot game (and thus devoid of reputation effects, credibility issues etc.). Likewise, the description will be of a two-candidate race, without the possibility of the entry of third candidates.

Such a model is not without its flaws, but is a reasonable analog for US presidential elections. Separate US presidential elections are generally felt to have limited dependence on one-another, essentially based upon the limited attention span and short memory of the archetypal voter. Furthermore, although there exists a history of third candidates in presidential elections, these candidates have, with the exception of Ross Perot, mainly been of trivial importance to the electoral outcome. In the case of Mr. Perot, whose campaigns lie beyond the chronological scope of this paper, it has been shown[22] that the primary impact a "serious" third candidate is to split the race into a trio of two-candidate races, within which voters behave as they would in a true two-candidate election.

For the same reason of simplicity, candidates will be considered as lacking an exogenous policy preference. Thus, their motivations are omitted. This restriction does

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21 Consider, for example, Gutowski and Georges (1993) or Osborne (1993).
22 For example by Alvarez and Nagler (1995).

not necessarily alter their strategic behavior[23], and has the benefit of removing the distortionary effects of an arbitrarily-defined policy preference.

Clearly, in a model subject to the rational voting paradox, alienation can have no real meaning, as strategic motivations in voting behavior have already been eliminated. Thus, for alienation to be a significant issue, the paradox must be overcome.

Let us assume for the moment that there are factors which overcome the paradox of rational voting. What effect does this have on voters, and in particular on the importance of alienation? If we assume that voters do have a rational motivation for participating in the election, this implies that they once again possess the ability to distinguish candidates from one another, and to choose between them, based on the candidates' policy positions.

The vital question is thus what form of strategic motivation the voters possess. However, it is most reasonable, I feel, to argue that *if* strategic motivation re-appears as the result of factors which overcome the rational voting paradox, then those factors should encompass the strategic motivation as well.

Thus, I intend to present a simple model, based upon an disaggregated version of Downs' own work, in which participation is rational, and in which alienation is a possible, but not necessary, outcome.

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23 As in Alesina (1988), wherein convergent or semi-convergent credible manifestos could be generated under either single-shot non-ideological games, or under multi-shot games with ideologically motivated politicians.

Section III: A simple model of participation

The Downsian view of participation may be expressed as follows. Turnout (at the aggregate level) is a function of the closeness of the race (R), the importance of the election (I), the difference between the candidates (D) and the costs (social, economic and otherwise) of participation (C). As such, turnout (T) is expected to take the form:

$$T = (R \times I \times D) - C$$

[3.1]

Thus, all things being equal, turnout will be higher when the race is close, when the election is important, and when the candidates are highly differentiated. The level of turnout will be lower when the net costs of participation are large. All in all, this seems a reasonable interpretation of group motivation to participation.

An individual voter's likelihood of participation (P_i) should be based on that individual's estimation of the closeness of the race (R_i), the importance of the election to the voter (I_i) and the voter's perception of the difference between the candidates (D_i), as well as the voter's personal costs from participation (C_i). The average of each of these individual terms should be the respective group term, and thus the turnout rate should be the average likelihood of participation by members of the population.

If interest is focussed on the first three terms in the agent's decision, the closeness of the race, the importance of the race and the difference between the candidates, then the paradox appears valid. Given even trivial costs of participation, it is hard to justify a claim that for an individual agent, who knows that his vote has effectively zero mass relative to that of the population, the benefits of voting outweigh the costs.

However, in a more complex model, especially one in which the agent's costs are considered in detail, the conundrum becomes less plausible. Firstly, an additional term should be entered into the agent's calculation of the *benefit* of voting. The agent must consider the effectiveness of his vote on the outcome, as well as the election's potential effect on him. Thus, the benefits of participation increase in closeness, importance and candidate differences as before, but decrease in the size of the overall voting population. Thus:

$$P_i \propto \frac{(R_i \times I_i \times D_i)}{N} - C_i$$

[3.2]

Secondly, and equally importantly, the agent's costs must be considered. The costs an agent faces in voting may be considered in three separate categories. There are physical and economic costs, such as the time taken, any loss of income incurred, and the physical effort required. These costs may reasonably be treated as lump sums. There are also social costs, both to participation and to abstention. It is reasonable to suggest that these costs are also lump sums, and that they are negative for those individuals for whom the social costs of abstention outweigh the social costs of participation. Lastly, there are ideological costs. These reflect the disutility generated by voting for a candidate who is less than the voter's ideal, and the risk of the election of a less-preferred alternative who is even further from the voter's bliss point.

The lump sum costs are particularly important. It has been argued[24] that there exist social benefits from voting which may offset the physical and economic costs of participation. These social benefits may be considered as negative costs, and are distributed across the population, such that given the political environment and even a voter's ideal policy, two otherwise identical voters may participate differently. The one who attaches high value to the social benefits of voting may participate in the election, but the other, whose overall lump sum costs are positive, does not.

The ideological costs reflect a voter's distaste for having to vote for a candidate who does not ideologically agree with the voter's own bliss point. It is reasonable to assume that these costs are likewise distributed across the population, but the distributions are not dependent on the political persuasions of the voters they cover.

A useful baseline in considering the magnitude of these costs would be that they are such that for those agents who gain the greatest social benefit from voting, even the most distasteful possible preferred candidate would not be so unpleasant as to generate positive overall costs. However, as some individuals gain almost zero social benefit from voting, those individuals would face positive overall costs even when the ideological costs were approximately zero, and hence would abstain even under "ideal" circumstances.

Thus, the agents costs may be considered to take the following form:

$$C_i = \gamma_i + f\left|x_i - x_i^{\bullet}\right|$$

[3.3]

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24 For example by Owen and Grofman (1996) and many other post-Downsian writers.

where γ_i, the fixed costs and benefits of voting, may be positive or negative, x_i represents the ideal policy for agent i, and x_i^* the policy of the *preferred* candidate. $f|x_i - x_i^*|$ thus represents the disutility caused by any difference between agent i's bliss point and the policy position of the preferred candidate, where $f > 0$.

Furthermore, the agent is aware that by *not* voting, he makes the election of the less preferred candidate more likely. However, by the same logic which generates the paradox to start with, the agent also knows that his personal decision has a negligible effect on the outcome, once the voting population is large. This assumption, however, is critical when confronted with concave agent preferences. Let us assume that voters *do* possess social cost structures which make them consider voting. Let us assume that they also possess some policy preference, and that part of their motivation to vote consists of a desire to see that policy (or one close to it) succeed in the election. If their aim is to maximize some form of utility which is dependent upon the policy outcome, and given a concave form for this utility function, it is clear that the agent will in general choose the candidate whose position lies closest to the agent's bliss point.

However, the agent must be aware that there exist *two* candidates, and hence that by not voting for the preferred candidate, the agent makes the success of the less-preferred candidate more likely. If the two candidates are separated from one another by a fixed distance, this leads to a problematic conclusion.

When the candidates are close to the agent's bliss point, the agent can see little difference between them (in terms of utility gained from the success of the preferred candidate over the less-preferred alternative). When the pair lie further from the agent's bliss point, however, the voter now sees a great difference between the possible outcomes, and thus has a far greater motivation to participate:

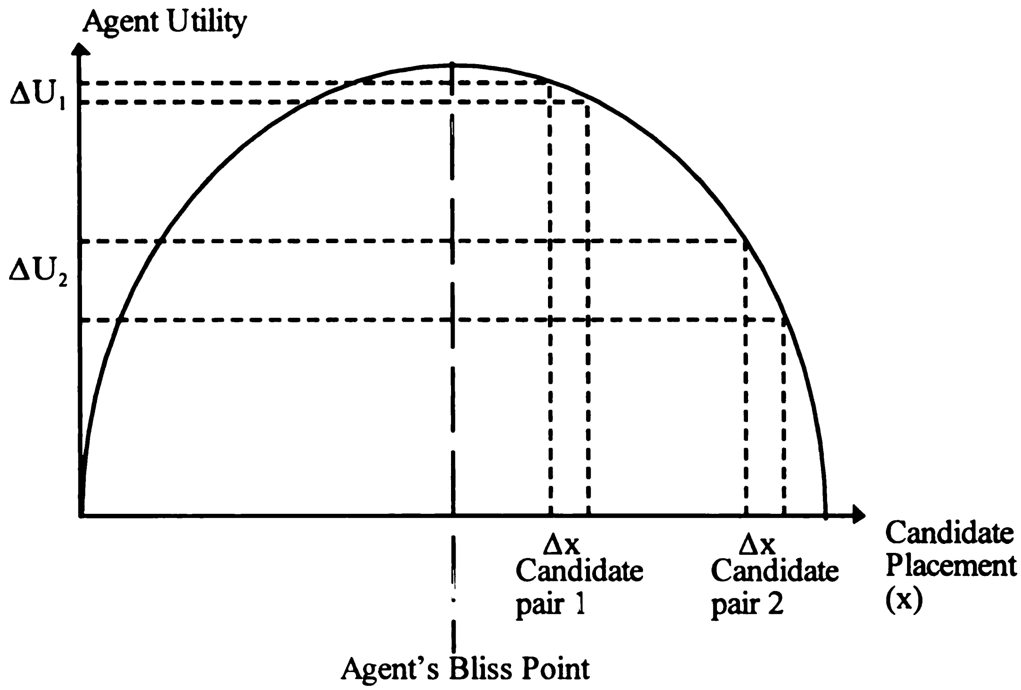

Figure 1 Proximity- and distance-sensitivity over candidate pairs.

As Δx is the same for the potential candidate pairs 1 and 2, but ΔU_1 is far smaller than ΔU_2, it would follow that voters with these preferences would have a much greater incentive to vote in a competition between pair 2 than between pair 1.

If this is so, then the following conclusions would seem reasonable:

- Given the location of either candidate, the greater the separation between the candidates, the more likely it is that the voter will participate

- The effect of the preferred candidate coming closer to the voter's bliss point should be smaller than the effect of the less preferred candidate moving away (as the slope of the utility curve would be far greater further away) by an equal displacement

Hence, given the separation of the pair of candidates, the closer that the pairing lie to the voter's preference, the smaller the difference in utility between the two outcomes, and hence the less likely that the voter will participate. In other words, alienation should be impossible, as those who should be alienated (i.e. those distant from the candidates) are in fact those with the *greatest* incentive to participate.

However, this is all predicated on the assumptions of uniform costs and that voters participate so as to bring about some particular policy. If alienation is present in electoral behavior, then there must exist some reason why voters whose bliss point lie far from the policy position of their favored candidate choose not to vote, while their more satisfied compatriots do vote. For such behavior to be rational, it must be true that either the dissatisfied voters face higher costs or lower rewards from voting.

Three alternative explanations could generate alienation under these circumstances. Firstly, it is possible that the voters do not face uniform costs, and that their costs are dependent on their position relative to those of the candidates. Secondly, it is possible that voters only consider the location of the preferred candidate in deciding to vote, i.e. they disregard the risk that their abstention will increase the likelihood of the less-preferred candidate being elected. Lastly, they may consider both of the candidates' positions, but their preferences may be drawn over a convex political utility function, such that they are more sensitive to changes in the location of candidates close to their bliss points.

In order to test these rival hypotheses, and indeed to determine whether alienation is present at all, I have adopted a form of the Downsian participation framework as the basis of a simple model of participation.

From Eq. 3.2, it is apparent that the "reward" to voting, within this context, should be based upon the importance and closeness of the race in question, and the difference between the candidates. However, the importance of the race and the closeness of the race are both independent of the voter's location on the policy spectrum.[25] The difference between the candidates, and particularly the relative separation of the candidates from the voter, clearly is dependent on both the voter's location and the voter's perceptions of the candidates' positions.

The difference between the candidate's locations (relative to that of the voter) may be seen to be $D_i = ||x_i - x_A| - |x_i - x_B||$. Thus, the reward to participation may be considered as:

$$\frac{(R_i \times I_i \times D_i)}{N} = \frac{(R_i \times I_i)}{N} \times D_i$$

$$= \left(\frac{(\bar{R} \times \bar{I})}{\bar{N}} + \varepsilon_i \right) \times D_i$$

$$= (\bar{\alpha} + \varepsilon_i) \times \left\| x_i - x_A \right| - \left| x_i - x_B \right\|$$

[3.4]

where x_A and x_B are the policy positions of candidates A and B.

Now, consider the position of the party preferred by agent i (either x_A or x_B, whichever is closest to x_i) as being denoted by x_i^*, and the position of the less preferred party by x_i^-. The distance between x_i and x_i^* is then $\vec{x}_i^*$, and the gap between x_i and x_i^- is $\vec{x}_i^-$.

As has been stressed previously, it is vital to know whether the agent's response to changing candidate positions is linear, proximity sensitive or distance sensitive. Thus, the rewards to participation, as expressed in Eq. 3.4 may be rewritten as:

$$(\bar{\alpha} + \varepsilon_i) \times (\beta_1 \vec{x}_i^- - \beta_2 \vec{x}_i^*)$$

[3.5]

where $\beta_1, \beta_2 > 0$.

If $\beta_1 = \beta_2$, then the voter's response is linear, whereas if $\beta_1 > \beta_2$, the agent's response is distance-sensitive, and if $\beta_2 > \beta_1$, the agent's response is proximity-sensitive.

From equations 3.3 and 3.5, it may be seen that

$$P_i \propto \left((\bar{\alpha} + \varepsilon_i) \times (\beta_1 \vec{x}_i^- - \beta_2 \vec{x}_i^*)\right) - \left(\gamma_i + f|x_i - x_i^*|\right)$$

[3.6]

hence

$$P_i \propto (\bar{\alpha} + \varepsilon_i)\beta_1 \vec{x}_i^- - \left((\bar{\alpha} + \varepsilon_i)\beta_2 + f\right)\vec{x}_i^* - \gamma_i$$

[3.7]

which is valuable to us, as if $(\bar{\alpha} + \varepsilon_i)\beta_1 > \left((\bar{\alpha} + \varepsilon_i)\beta_2 + f\right)$, then $\beta_1 > \beta_2$, whereas if $(\bar{\alpha} + \varepsilon_i)\beta_1 < \left((\bar{\alpha} + \varepsilon_i)\beta_2 + f\right)$ then either $\beta_2 > \beta_1$ or f is large.

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[25] Note that this does not imply that these values are constants, merely that their individual values depend upon matters *other* than the location of the voter on the policy scale.

Thus, by comparing the voters' participation rates to differences in the candidates' positions, we posses a test which should indicate whether the agents are distance sensitive, or alternatively either proximity-sensitive in their response to policy issues or strongly proximity-sensitive in their ideological costs.

This model, derived as it is from Downs' simple model of turnout, treats candidate placement as exogenously determined. From a theoretical perspective, this is invalid. Given rational voters, we can only assume the presence of rational politicians. Rational politicians, aware of the process by which voters determine whether or not to vote, should choose their positions so as to maximize their utility, presumably by being elected.

However, such a view of political actions has two inherent flaws for the purpose of this paper. Firstly, by making candidate placement an endogenously determined characteristic, the model loses the simplicity and flexibility which gave it its elegance.

Secondly, while the best available dataset with corroborated evidence of participation and abstention (the NES survey) contains 2000 individual data points per year, it can only contain a single candidate placement pair per election, and thus the issue of candidate placement is starved of data.

Furthermore, it has been widely argued that candidate placement is not solely, or even primarily, determined by considerations of electoral strategy. While undoubtedly such considerations are important, internal party politics and the wishes of the usually small, ideologically motivated grassroots of the party are paramount in the selection of the party's candidate, and that candidate's choice of policy position. Further anecdotal evidence of this may be seen in the lack of total convergence which characterizes U.S.

elections. In electoral games in which victory is the dominant motivation for candidates, the equilibrium outcome is almost uniformly convergent at something approximate to the median voter.

A further impediment to incorporating candidate strategy is that what is most important, in general, is voter's perception of the candidates' strategies, rather than those strategies *per se*. While constructing a theory of candidate placement is difficult, constructing one from the voters' perceptions of candidate strategies is all but impossible, and certainly would prove an inadequate base from which to try to draw empirical conclusions.[26] Thus, in this paper, I intend to treat candidate strategies as exogenously given.

Section IV: Testing for the presence of alienation

The question of the presence of alienation implies three subsidiary questions, all of which must be answered to some degree in order to understand the interaction of candidate placement and voter abstention.

Firstly, there is the question as to whether or not voter behavior appears consistent with the presence of alienation. For this, all we require is that voters whose preferences are markedly different from those of the candidates are less likely to participate.

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26 Attempts to "reveal" either the voters' true preferences or the candidates true positions have either had to rely upon the (dubious) assumption of sincerity, or have otherwise proved inconclusive. Dasgupta (1996) demonstrated simultaneously the theoretical possibility and practical uncertainty of attempting to reveal the tactical motivations behind candidate strategy.

Secondly, we must ask whether or not it appears that this voter behavior *is* caused by alienation, or rather by some other institutional or strategic factor. To answer this question, the agents behavior must be conditioned upon their age, sex, income and level of interest in the political debate.

Lastly, if it appears that alienation is responsible for some of the observed behavior of voters, we must ask what form of strategic preference and implicit cost structure lies behind the observed alienation. In order to do this, is necessary to try to establish whether the agents utility functions over political questions are proximity sensitive, or whether the agents simply consider the location of the preferred candidate, and thus ignore the less preferred candidate, and his potential effect on policy, or whether, instead, the agents' costs are proximity-sensitive to a sufficient degree to overwhelm conventional distance-sensitive utility functions. Any of these three hypotheses could justify rational alienation, however, their implications for the nature of voter behavior and hence candidate strategy are widely different.

The data used in this paper originated in the National Election Survey (NES) under the auspices of the Inter-university Consortium for Political and Social Research (ICPSR)[27], covering the 1980, 1984 and 1988 US presidential elections[28]. The survey for these years consist primarily of a pair of interviews, each lasting about 1 hour, and the Vote Validation Survey, wherein the registration records of the respondents were checked

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27 Inter-university Consortium for Political and Social Research, PO Box 1248, Ann Arbor, Michigan 48106

28 Data from the 1992 and 1996 elections were omitted, as the definition of voter participation was neither internally consistent nor reasonably reliable, as data from actual registration records are not available for 1992 and 1996. Although a summary variable (constructed by the interviewer) for participation *does* exist, it is only comparable with the previous self-evaluation of participation rather than the cross-checked registration record.

to determine exactly who had voted (rather than relying on the highly inaccurate basis of the respondents' claims to have voted).

Survey households were selected based upon a complex weighting system derived from US Census data. Individual respondents from these households were selected on a random basis.

The data for each year contains responses from approximately 2,000 interviewees, each of whom (other than those who failed to respond to repeated requests) was interviewed twice, once in the three months prior to the election, and once in the three months after the conclusion of the campaign. To a large degree, these interviews were close to the actual polling day (e.g., during the 1988 survey, 55% of the post-election interviews had been carried out by November 21st, and 82% by December 5th).

While it was naturally impossible to interview *all* of the initial respondents after the election, overall approximately 87% of the sample were interviewed on both occasions. Of those who were not re-interviewed, however, the majority still yielded some post-election information via the vote validation survey.

The validation survey was deemed successful in approximately 95-98% of the cases, the remainder representing a mixture of those who did not give their name, or whose registration records were unavailable.[29]

From the wealth of information obtained in these interviews, certain variables are of prime interest to the question of candidate placement and voter behavior. First among

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29 Naturally, there also existed a sizable group for whom no registration records could be found (approximately 15% of the survey cases), but these were reasonably classed as non-voters in most cases. Furthermore, validation was not carried out on all respondents if the respondent in question claimed to be unable or unwilling to vote (for example, those who claimed not to be registered), as the tendency to vote

these, of course, is the outcome of the validation test: i.e. whether or not the agent actually participated. Secondly, there are a conventional set of terms covering the agent's demographic and economic characteristics. Thirdly, there are a range of political questions, from which the agent's views may be determined.

The validation results are obviously of vital importance, as only they reveal the *actual* participation or abstention of the voter, rather than simply the indicators for likely participation, such as interest in the campaign, party membership etc.

The demographic and economic variables are largely self-explanatory. Principal within the group are terms for age, sex, race and income. The age variable simply enumerated the respondents age, either as given to the interviewer, or as estimated by the interviewer. Sex was taken to be equal to zero for female respondents and one for males. Race was based on a score of zero for non-white respondents and one for whites, the classification again being either that which was given by the respondent or that which was estimated by the interviewer.

The income variable recorded the middle income (in 1984 dollars) within 23 bands from an income of less than $3000 per annum (treated as zero dollars) to over $90,000 (treated as $100,000) per annum. Of the interior bands, eleven were located at annual incomes of less that $20,000, with seven more for incomes between $20,000 and $50,000, leaving three bands for incomes between $50,000 and $90,000.

The political variables consist of a number of non-candidate attributes, such as interest in the campaign, party affiliation (if any) and the respondent's level of information about the election, and two scales based upon candidate placement. These

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while claiming not to is considered trivial by comparison to the likelihood of not voting while claiming to two scales are a 7-point Liberal:Conservative scale on which the respondent must place themselves, along with the two nominees, and a thermometer scale, which measures the respondent's satisfaction with the nominees, other leading figures and the two political parties. While the Liberal:Conservative scale is technically a purer representation of candidate placement, it suffers from being only a uni-dimensional measure of position, whereas the thermometer reading, serving as a proxy for a multi-dimensional placement system (such that the worse a candidate's thermometer score, the greater the overall separation of that candidate's multiple positions from the agent's preferred positions) may be considered a broader and (as a 100 point scale)[30] more refined representation of voter approval of the candidate's policy positions.

A number of subsidiary variables were created from these two placement scales to convert them into the relevant measures of distance and quality. In the case of the Liberal:Conservative scale, this process consisted of determining the distance between the respondents' self-assessment of their locations on the scale and the respondents' views of the candidates' positions.

For the thermometer scale, more information was available in the dataset. As well as the nominee's thermometer scores (both before and after the election), respondents also gave scores (prior to the election) for the parties themselves, as well as for three alternative "leading lights" from both parties[31]. Clearly, these scores are not directly analogous to a distance scale. Nevertheless, it seems reasonable to assert that an ideal

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have participated.

[30] Although many respondents stuck rigidly to 5-point increments, rendering it a 20-point range instead.

[31] Typically, these were the individuals among the leaders of the parties who either stood for nomination or might have been expected to stand. As such, over the course of the three presidential

candidate, one who matched the respondent perfectly on every issue, would score a perfect 100, while a candidate who uniformly opposed the respondent's views would be given a zero. Thus, the measure of distance-to-candidate was formed simply from the difference between an ideal candidate (who would score 100) and the actual nominee's score.

As can be seen from Table 1a, using the thermometer scale, few respondents (20% of those surveyed) gave the best available candidate a score of over 90, while very few (less than 10%) gave the less-preferred candidate a score in the range 0-10. Indeed, while 75% of the respondents gave their preferred candidate a score between 70 and 100, the distribution of scores to the less-preferred candidate was approximately uniform.

Thus, most voters avoided the temptation to polarize their stated views of the candidates. The mean score of the preferred candidate was approximately 76, while the mean for the less-preferred rival was about 40. The perceived separation of the candidate scores appears to be distributed in a manner close to a truncated normal (the more significant truncation being at 0, and less significantly at 100) around a score of approximately 30-40, but with significant tails out to a separation of > 90.

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elections covered, several names recurred (e.g. George Bush, as Vice Presidential nominee for Ronald Reagan and as Presidential nominee in his own right, in 1988.

Table 1a Candidate scores and separation, using the thermometer scale

Table 1a Candidate scores and separation, using the thermometer scale

Variable:	Mean:	Std. Dev.:	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-100
Score of preferred candidate	76.18	*17.54*	0.5%	0.5%	0.0%	1.0%	1.5%	8.5%	13.5%	24.5%	30.0%	20.0%
Score of less-preferred candidate	40.62	*23.05*	13.0%	9.5%	1.0%	11.5%	15.0%	23.0%	15.0%	8.5%	3.0%	0.5%
Separation of candidate scores	36.28	*27.71*	13.0%	16.5%	14.5%	13.0%	11.0%	10.5%	4.0%	7.0%	5.5%	5.0%

The percentile figures refer to the proportion of the population holding a given view of the candidates.

Table 1b Distances to candidates and candidate separation, using the Liberal:Conservative scale

Variable:	Mean:	Std. Dev.:	0	1	2	3	4	5	6
Distance to preferred candidate	1.005	*0.947*	31.6%	45.6%	16.2%	4.4%	1.7%	0.4%	0.1%
Distance to less-preferred candidate	2.888	*1.423*	3.3%	13.0%	26.8%	23.3%	19.6%	10.0%	4.0%
Separation of candidates	2.629	*1.489*	8.9%	15.5%	22.4%	22.3%	20.9%	8.0%	2.0%

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From Table 1b, it can be seen that analogous patterns appear in the data concerning the Liberal:Conservative scale. The mean distance to the preferred candidate is approximately 1.0, while the mean distance to the less-preferred candidate is nearly 3. The apparent anomaly that the mean separation of the candidates is more than 2.6 (and hence close to the mean distance to the less-preferred candidate) is explained by the number of respondents (850 from a total sample of 5911) who felt that they were straddled by candidates on either side of their own position.

As outlined above, the dataset was tested so as to offer answers on three issues; whether or not dissatisfied voters are less likely to participate than those who are pleased with their preferred candidate, whether or not such behavior is accounted for by alienation, or rather by institutional and demographic factors, and if alienation is found, the form it seems to take.

As a starting point, Table 1c shows the average probability of participation among individuals with given positions on the Liberal:Conservative scale.

Table 1c Average participation in different self-assessed political positions

Liberal:Conservative Placement (1-7)	1	2	3	4	5	6	7
Participation Rate	70%	65%	63%	59%	66%	71%	75%
(Number of respondents)	*(217)*	*(433)*	*(623)*	*(802)*	*(1083)*	*(785)*	*(364)*

Voters were asked to place themselves on a 7 point scale from 1 (extremely liberal) to 7 (extremely conservative). As can be seen, there is little overall difference in participation between the two tails of the distribution, while it appears that participation was lower among those in the middle-ground.

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Testing the null hypothesis that the mean participation rate for groups 3, 4 and 5 (62.9%) was in fact the same as the mean for the other groups (70.3%) led to the rejection of the null hypothesis at the 5% and 1% levels.[32]

This "softness" of support in the center is consistent with either a proximity-sensitive or distance-sensitive model of voter participation, as centrist voters are most likely to be "straddled" by the two parties and thus face different but equivalently distasteful alternatives.

It should be noted that the vast majority of respondents placed the candidates within the range of 3-5, i.e. in broadly centrist positions. Thus, while the highest participation rates were seen at the extremes of the scale, this was not the location chosen by most candidates.

In a more complex framework, Table 2 shows the results of a series of regressions performed on the 1980-1988 combined dataset, in which *recorded* participation (as opposed to claims of participation) was regressed upon terms relating to the distance from the respondent's position to that of the best candidate on offer (a measure of sub-optimality), and the difference the respondent perceived between the two candidates (a measure of candidate differentiation).

It should be noted at this stage that as the behavior modeled in this paper concerns discrete choices, it would be natural to conduct the analysis using a Logit or Probit technique, rather than OLS and the linear probability model.

However, the coefficients derived from such analyses are not easily translated into intuitively meaningful values, and when the dataset is conventional (especially in that the

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32 The 95% confidence intervals for the participation rates among members of the mid-range and the

majority of predicted participation rates fall between 25 and 75%), the results of the OLS and Logit regressions should be similar around the mean predicted participation rate. For ease of interpretation, the results presented in the body of the paper are from OLS regressions. Appendix 1 details a comparison of the results gained from Logit, Probit and OLS techniques, and demonstrates that the results are not significantly affected by the choice of modeling strategy.

From Table 2, it is clear that for any of the first four models, using either pre-election (model A) or post-election (model B) data, or comparing the candidates to one another (model C) rather than to the ideal, or using the Liberal:Conservative scale (model D), the same pattern is consistently replicated, other than in model C, where an inferior measurement of candidate quality is used, as described below. In all of the other models, as candidate quality falls, so does participation. Likewise, as the difference between the candidates increases, participation will rise. It should also be noted that the constant term dwarfs the effects of placement, even if candidate quality was to move from 0 to 100 (or 0 to 7 for the alternative scale), or if candidates were to converge completely from the political poles.

Such results are consistent with the preliminary expectations laid out so far. That the constant term is very large relative to the placement terms is neither surprising nor worrying, as the coefficients still are significant and remain the only characteristics under the candidate's control. The constant, in these sparse regressions, encapsulates all of the demographic, social and non-strategic political characteristics of the voter and the election.

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whole survey being (61.0% to 64.7%) and (64.6% to 67.4%) respectively.

Table 2 **Sparse regressions of participation as based upon candidate placement and quality**

Table 2 Sparse regressions of participation as based upon candidate placement and quality

Model Specification:	Adjusted R^2, *(number of observations)*	Prob > F-stat	Coefficient on distance to preferred candidate *(S.E.)*	Coefficient on candidate differentiation *(S.E.)*	Constant Term *(S.E.)*
A	0.0166, *(5217)*	0.0000	-.0018938 *(.0004705)*	.0013725 *(.0002934)*	.6214261 *(.0204774)*
B	0.0156, *(4850)*	0.0000	-.0016705 *(.0004912)*	.0014762 *(.0003362)*	.6327911 *(.0226131)*
C	0.0139, *(5217)*	0.0000	-.0006687 *(.0005369)*	.0019749 *(.0002484)*	.5596881 *(.0126696)*
D	0.0175, *(3492)*	0.0000	-.0152427 *(.0077034)*	.0394652 *(.0053511)*	.6000697 *(.0195149)*
E1	0.0136, *(5318)*	0.0000	.0032375 *(.0003759)*	N/A	.3746358 *(.0294127)*
E2	0.0043 *(5318)*	0.0000	.0014069 *(.0002880)*	N/A	.6784251 *(.0134151)*

Note: As specifications A, B, C, E1 and E2 are based on the 100-point thermometer scale, and D is based upon the 7-point Liberal:Conservative scale, the coefficients from the former are not immediately comparable to those of the latter.

The model specifications were as follows:

- Model A was performed using the thermometer scale, taken *prior* to the election.
- Model B was identical, except using the *post-election* thermometer scores.
- Model C used a different definition of quality to A and B, wherein rather than comparing the better of pre-election scores for the two nominees to the *ideal* candidate, the better nominee was compared with the highest score achieved by either of the parties, their candidates, or the alternative candidates.
- Model D was based upon the 7-point, uni-dimensional Liberal:Conservative scale.
- Model E1 simply regressed participation on the pre-election thermometer score of the preferred candidate, while E2 regressed participation against the pre-election score of the less-preferred candidate

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Theory and intuition tell us that the separation of the candidates should be significant, and that as candidate differentiation increases, so should the incentive to participate.

Most important, obviously, is the result on the quality (as measured by the distance to the preferred candidate) term. As the quality of the best available candidate falls (i.e. the distance increases), so does participation, *even given* the separation of the two candidates. Thus, as the voter becomes more distant from a pair of candidates who are set a fixed distance apart, the voter becomes less likely to vote, not more.

Models A and B are clearly mutually supportive. The slight difference in coefficient values between them may readily be attributed to the overall decrease in voters' opinions of the candidates after the election, such that candidates seemed more inferior (lowering the coefficient on lack of quality) and less different (increasing the coefficient on separation) than before.

These models indicate that improving the quality of the preferred candidate by 1° before or after the election would lead to a .19% or .17% increase in the likelihood of participating. Similarly, increasing the perceived separation of the candidates by 1° would have led to a .14% or .15% increase in participation.

Model C, which compares the potential candidates to one another, rather than to the ideal, contains a somewhat greater coefficient on candidate separation (at .19% increase in participation per 1° increase in separation), but a markedly lower (.07% per 1°) coefficient on quality. Furthermore, this coefficient is insignificant at the 5%, 10% or even 20% confidence levels.

It transpires that this weakness is in fact primarily a function of the modified quality variable in use in model C. Whereas the previous quality term measured the difference between the best nominee and the ideal candidate, in model C it compares the candidates to the best of a small group of leading politicians. Given an almost infinite number of potential candidates, there should exist at least one who would score a 100 on the thermometer scale. If a respondent feels that none of the eight nominees and leading politicians deserves a high score then that (highly dissatisfied) agent would appear to have a very low sub-optimality score as measured by model C, but his or her displeasure becomes apparent under models A and B. For those agents who already felt that one of the eight possibles was very good, the effect of changing the definition of preferred-candidate sub-optimality from model A to model C is negligible.

Model D offers broadly similar results to models A, B and C[33]. In this case, a 1-point increase (on the 7 point Liberal:Conservative scale) in the distance between the voter and his or her preferred candidate translates into a 1.5% decrease in the likelihood of participation, while a 1-point decrease in the separation of the two candidates would lead to a 4% decrease in participation. The marginally lower level of significance of these results may well be attributable to the problem of modeling a multi-dimensional process, such as the decision to vote, through a uni-dimensional scale (the candidate's placement on the Liberal:Conservative scale). For agents to whom liberality is not a key issue, model D says little, whereas for those to whom it is vital, the same evidence will appear (along with further information) in the multi-dimensional thermometer scale.

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[33] Furthermore, to demonstrate that the results described so far are not merely the result of the terms' mathematical construction, if the above regressions are run with a mixture of the two scales (thermometer and Liberal:Conservative (which are mathematically unrelated)) the same general patterns do emerge.

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Furthermore, given that the Liberal:Conservative scale encompasses only seven distinct positions, as opposed to 100 on the thermometer scale, we would expect the coefficients from the thermometer-based regressions to be approximately 1/14th the size of those from the uni-dimensional scale. However, it is apparent that the coefficients from the Liberal:Conservative scale are considerably smaller than this expectation. This would seem to lend further credence to the belief that the Liberal:Conservative scale is at best a weak proxy for candidate (and voter) placement.

Owing to the inherent flaws in models C and D, as well as the smaller independent sample for model B, model A was retained as the "baseline" against which alternative regressions were tested.[34]

The two E-models, in which participation was regressed solely on the score of the preferred (model E1) or less-preferred (E2) candidate, must be considered together. Comparing E1 to E2, clearly the effect of a 1 degree increase in the quality of the preferred candidate leads to a far greater increase in participation (model E1, (.32%)) than a corresponding decrease in the quality of the worse candidate (E2, (.14%)). This result is completely at odds with the hypothesis that voters are sensitive to distance, not proximity. This difference between the coefficients is sufficient to reject the null hypothesis that the values are equivalent at the 5% level.

Despite these promising results, it must be acknowledged that demographic characteristics are highly significant in determining the agent's likelihood of

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[34] Although model B is based on only a slightly smaller sample, it is dubious to claim that those individuals who were "lost" from the sample were identical to those who were retained. As would be expected, they tended to have a lower level of interest in politics, and as a result were less likely to participate, as well as having markedly different views of the candidates, as compared to the sample as a whole.

participation. Table 3 shows the effects of the presence of key demographic terms on the coefficients for sub-optimality and candidate separation.

Table 3 Candidate placement and quality coefficients in the presence of assorted demographic characteristic terms.

Model :	Adjusted R^2, *(number of observations)*	Prob > F-stat	Coefficient on distance to preferred candidate *(S.E.)*	Coefficient on candidate differentiation *(S.E.)*	Demographic Terms Present
A	0.0166 *(5217)*	0.0000	-.00189 *(.00047)*	.00137 *(.00029)*	None
F	0.0747 *(4611)*	0.0000	-.00072 *(.00049)*	.00174 *(.00030)*	Age, sex, race, income

Note: Income is based upon the median income from the respondent's selection of one of approximately 22 income bands, based on 1984 incomes.

Clearly, in model F, (which contains data on age, sex, race and income) the candidate placement coefficients are significantly different from model A. In model F, however, preferred-candidate sub-optimality is significant only at the 15% level. This would, initially, appear to suggest that the candidate quality term acts as a proxy for age, and hence that agents use candidate differentiation (which remains significant at the 5% level) as the sole determinant of their strategic (as opposed to social) behavior.

This does not, however, appear to be the case. The reason that sub-optimality is no longer significant is that there is a correlation (with a correlation coefficient of -.114) between age and suboptimality, as shown in Table 4:

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Table 4 Regressing preferred-candidate sub-optimality on: age, sex, race and income

suboptimality	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
age	-.1187465	.0138451	-8.577	0.000	-.145889	-.091604
sex	.5254114	.5315969	0.988	0.323	-.5167502	1.567573
race	.9049686	.7051564	1.283	0.199	-.4774452	2.287383
income	.0000148	.0000159	0.931	0.352	-.0000164	.0000461
constant	27.49609	.8825369	31.156	0.000	25.76594	29.22625

Thus, older voters regard their favored politicians more highly, and as a result, if age and suboptimality are both present in the regression, the significance of suboptimality is greatly diminished. Note: this effect is not present for race, sex or income, just age.

This could, however, be taken as an indication that suboptimality was serving merely as a proxy for age. This seems not to be the case, in the light of age-specific results obtained from subsequent heterogeneity testing.

The population was split into four age-based quartiles, with the following age ranges: group 1 = (17 to 29), group 2 = (30 to 40), group 3 = (41 to 58) and group 4 = (59 to 99). Table 5 shows the results obtained by running model specification F, which includes age, sex, race and income data, and four age-specific regressions on sex, race and income.

Table 5 Candidate placement and quality coefficients within specific age groups.

Group	Adjusted R^2	Prob > F-stat	Coefficient on distance to preferred candidate *(S.E.)*	Coefficient on candidate differentiation *(S.E.)*	Age range
(Model F)	0.0747	0.0000	-.00072 *(.00049)*	.00137 *(.00029)*	17-99
1	0.0416	0.0000	-.00170 *(.00089)*	.00230 *(.00060)*	17-29
2	0.0308	0.0000	-.00175 *(.00087)*	.00154 *(.00059)*	30-40
3	0.0418	0.0000	-.00063 *(.00085)*	.00090 *(.00056)*	41-58
4	0.0369	0.0000	-.00218 *(.00084)*	.000924 *(.00056)*	59-99

As can be seen, the results are broadly consistent for groups 1, 2 and 4, and appear to overcome the problems shown by model F, but not for group 3. In group 3, neither the coefficient on candidate quality nor that on candidate differentiation is significant at the 5% or 10% levels. Indeed, neither of the placement-based coefficients is significant even if the other is not present at all.

It is initially difficult to explain why this particular group should respond in such a markedly different manner from the other groups in the dataset. The problematic behavior appears to be centered around a group of approximately 500 individuals with ages between 44 and 51 (i.e. if the 2^{nd} and 4^{th} quartiles are "stretched" to incorporate those aged 40-43 and 52-58 respectively, then the revised 2^{nd} and 4^{th} groups still generate results consistent with those in Table 5).

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This group does not appear to be demographically, economically or politically different from the rest of the sample[35]. The only respect in which they differ meaningfully from the sample as a whole or from the groups above and below them is in the effect of the respondents who "dropped out" between the first and second interviews (but whose verification data remains available, even though they were only interviewed once). If model F, with which concern over age-related problems arose, is re-run in the absence of those who dropped out of the survey (as in model G, below), then although age remains a significant term, it no longer interferes with the coefficients on either suboptimality or candidate differentiation. Very similar results are obtained by deleting only those respondents whose age lies between 44 and 51 (model H), as can be seen in Table 6.

Table 6 The effect of eliminating specific age groups or interview dropouts

Model	Adjusted R^2 *(number of observations)*	Coefficient on distance to preferred candidate *(S.E.)*	Coefficient on candidate separation (S.E.)	Demographic terms present	Restrictions
F	0.0747 *(4611)*	-.00072 *(.00049)*	.00137 *(.00029)*	Age, sex, race, income	None
G	0.0718 *(4441)*	-.00121 *(.00051)*	.00135 *(.00034)*	Age, sex, race, income	No dropouts
H	0.0771 *(4120)*	-.00106 *(.00052)*	.00163 *(.00032)*	Age, sex, race, income	Age <44 or >51

This leads to the possibility that the "problem" with the respondents in the third quartile relates not to their voting behavior or their political views, but rather, in some manner, to their reaction to the survey. Specifically, it may be the case that their scores

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reflect either a flippancy of a lack of honesty in their responses. This suggestion appears to be borne out incorporating a measure of honesty into the sample selection criteria.

During the second interview, respondents were asked whether or not they voted, and this was then checked, as part of the vote verification survey. Comparing the claim of participation to evidence of participation, a new variable, *truth*, was constructed, with value 1 when the respondent's answer appears to be a lie, and zero if the respondent appears to have told the truth.

It should be noted that the number of confirmed liars amounted to only approximately 7% of the population of either the survey or the 3rd quartile.

Survey participants who did not take the second interview were coded as *truth*=2. These individuals may have been prepared to tell the truth or lie, but in the absence of a second interview, it is impossible to tell.

However, by simply omitting respondents whose truth score was 1 (i.e. who definitely lied), and hence retaining all those respondents who either told the truth or who did not attend a second interview, the coefficient on suboptimality is significant at the 5% level across all age groups (model I) and within the third quartile (model J), as can be seen in Table 7.

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behavior is not replicated within other, equally conservative subsets of the data.

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Table 7 The effects of eliminating liars

Model	Adjusted R^2 *(number of observations)*	Coefficient on distance to preferred candidate *(S.E.)*	Coefficient on candidate separation (S.E.)	Demographic terms present	Restrictions
F	0.0747 *(4611)*	-.00072 *(.00049)*	.00137 *(.00029)*	Age, sex, race, income	None
I	0.0959 *(4229)*	-.00113 *(.00049)*	.00184 *(.00030)*	Age, sex, race, income	No confirmed liars
J	0.0512 *(1028)*	-.00164 *(.00081)*	.00101 *(.00054)*	Age, sex, race, income	No confirmed liars, 3rd quartile only

It transpires that the cause of these problems lies not in the number of dishonest individuals within the four quartiles, which are almost identical[36], but rather in the nature of their dishonesty.

The mean suboptimality score for the sample as a whole is approximately 23.8 (i.e. a candidate score of 76.2), and this mean is not politically or statistically significantly different from the means of the honest members of the 1st 2nd and 4th quartiles (24.4 average) or the dishonest members of those groups (23.4) or the honest members of the 3rd quartile (23.0). It is, however, very different from the mean of the dishonest members of the third quartile (17.9). A test of the null hypothesis that the mean score of 1st 2nd and 4th quartile liars is equal to that for liars in the 3rd group can be easily rejected at the 1% level.

While there is no apparent explanation as to why one particular age range should contain individuals whose dishonesty is so radically different from that of the sample as a whole, it is clear that the presence of such behavior generates an apparent and problematic correlation between age and suboptimality which is derived primarily from

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[36] For example, there are 96 confirmed liars in the 3rd quartile, among a total number of 423 liars.

the irresponsibility of the dishonest members of the 3rd quartile, rather than from any underlying political or demographic characteristics.

As such, once this unreliable data has been dropped, a proximity-sensitive picture once again emerges, even in the presence of the conventional set of demographic predictors of participation (as in model I in Table 7).

Similarly, if the same tests are performed on models derived from the Liberal:Conservative scale, and hence from model D, then when the age characteristic is present (as in model K) it again removes the significance of the sub-optimality term, as seen in Table 8:

Table 8 Candidate placement and quality coefficients in the presence of assorted demographic characteristic terms, as measured on the Liberal:Conservative scale.

Model:	Adjusted R^2, *(number of observations)*	Prob > F-stat	Coefficient on distance to preferred candidate *(S.E.)*	Coefficient on candidate differentiation *(S.E.)*	Demographic Terms Present
D	0.0175 *(3492)*	0.0000	-.0152 *(.0077)*	.0394 *(.0053)*	
K	0.0589 *(3156)*	0.0000	-.0149 *(.0089)*	.0331 *(.0055)*	Age, sex, race, income
L	0.0777 *(2892)*	0.0000	-.0224 *(.0086)*	.0346 *(.0053)*	Age, sex, race, income

Note: Model L omits those respondents who were demonstrated to have lied about their participation.

Again, the decrease in the significance of suboptimality between models D and K is largely attributable to the presence of members of the third age quartile who transpire to have lied about their participation, as in was the case with the thermometer scale. In model L, as with model I in Table 7, removing proven liars from the sample greatly in

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increases the significance of the coefficient on the distance to the preferred candidate. However, the inherent weakness of the uni-dimensional Liberal:Conservative scale makes models D, K and L less informative than the thermometer based equivalents (models A, F and I from Tables 2 and 7).

If the minimalist E-models are combined, and participation is regressed against *just* the score of the better candidate and the score of the worse candidate (as in model M in Table 9a), or against those terms and the demographic characteristics (model N in Table 9a), then again a proximity-sensitive view of participation emerges.

If we continue to assume that the candidates' scores are some form of proxy for their positions relative to the voter, then proximity-sensitivity would indicate that if the gap between the candidates was fixed, but the candidates moved closer to the voter, the voter should have more incentive to vote.

Table 9a Candidate placement coefficients in the presence of assorted demographic characteristic terms.

Model:	Adjusted R^2, *(number of observations)*	Prob > F-stat	Coefficient on Preferred Cand. *(S.E.)*	Coefficient on Less-Preferred Cand. *(S.E.)*	Demographic Terms Present
M	0.0191 *(5318)*	0.0000	.00339 *(.00038)*	-.00159 *(.00029)*	None
N	0.0769 *(4618)*	0.0000	.00259 *(.00040)*	-.00190 *(.00030)*	Age, sex, race, income

Although the value of the coefficient on the preferred candidate falls in the presence of the demographic characteristics (model N), it remains considerably larger than that on the less-preferred candidate. The coefficient on best candidate's score is 0.0026, and that on the worse is -0.0019. Consequently, if the thermometer scores of *both* candidates rose by ten degrees (i.e. both candidates moved closer to the voter's preference by the same amount), then the net effect would be an *increase* of .7% in voter participation.

However, in model N, we cannot reject the null hypothesis that the two key coefficients are in fact equal but opposite in sign, i.e. that $\beta_{preferred} = -\beta_{less\text{-}preferred}$ at the 95% or 90% confidence levels.[37]

This discrepancy is yet another result of the lack of honesty of some respondents, particularly in the 3rd age quartile. If model N is re-written to exclude age (but to still include race, sex and income), as in model O in Table 9b, then the magnitudes of $\beta_{preferred}$ and $\beta_{less\text{-}preferred}$ are significantly different at the 5% level, as can be seen in Table 9b.[38]

It should be noted that in none of these models, nor in any of the other models cited here, did the choice of conventional standard errors (rather than heteroskedasticity robust standard errors) have any meaningful impact on the significance of any coefficients.[39]

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[37] The coefficients are only significantly different in magnitude at approximately the 85% level, based on an F-test of $F(1, 4674) = 1.99$, and hence Prob > F = 0.1580.

[38] In this case, the appropriate test of the "equal but opposite" hypothesis yields an F-test of $F(1, 4290) = 4.77$ and hence Prob > F = 0.0291.

[39] For example, while in model O the conventional standard error on the score of the preferred candidate was (0.00039), the robust one was only slightly higher at (0.00041). Likewise, the coefficient on suboptimality in model I has a conventional standard error of (0.00049) while the robust equivalent is only (0.00051).

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Table 9b Candidate placement coefficients in the presence of demographic characteristic terms, other than age.

Model:	Adjusted R^2, *(number of observations)*	Prob > F-stat	Coefficient on Preferred Cand. *(S.E.)*	Coefficient on Less-Preferred Cand. *(S.E.)*	Demographic Terms Present
O	0.0992 *(4297)*	0.0000	.00311 *(.00039)*	-.00205 *(.00030)*	Age, sex, race, income

Note: Model O omits those respondents who were demonstrated to have lied about their participation.

Under this model specification, if the thermometer scores of both candidates rose by ten degrees, then the net effect would be an increase of *1.06%* in voter participation.[40]

Section V: Preliminary evidence of the voters' costs and preferences

From all of the results described in Section IV, and many others which were carried out simultaneously, it is apparent that voters' participation decisions do appear consistent with the concept of alienation. Those who view the preferred candidate as low quality consistently are less likely to vote than those whose preferred candidate is closer to the ideal, even given the voters' perceptions of candidate separation.

Furthermore, these results persist even when the conventional demographic factors which are assumed to "drive" participation rate differences are present, once the influence of perceptibly dishonest respondents has been removed. These results offer

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40 It should be noted that the candidate-placement coefficients and their standard errors from models M and K are almost identical, as the effects of sex, race and income do not alter the pattern of voter response to candidates. Instead, sex, race and income set the pre-conditioned level of participation, and hence predominantly affect the size of the constant term.

answers to the first two questions posed at the start of Section IV. However, the third question, of the motivations which drive the alienated behavior, is less clearcut.

To reiterate, three potential explanations of alienation in the face of rational voters seem reasonable. First, the voter may possess preferences which are mapped only over the policy position of the preferred (or less-preferred) candidate, and hence the voter disregards the consequences of the electoral outcome. Secondly, the voter's political utility function may be convex, such that the rate of increased disutility suffered from unsatisfactory outcomes diminishes in the distance of those outcomes from the voter's ideal, i.e. the voter is proximity-sensitive. Lastly, the voter's costs may be sufficiently proximity-sensitive that even with a concave political utility function, the overall response to candidate placement is most pronounced in close proximity to the voter.

From the results described in Section IV, it seems reasonable to eliminate the first of these possibilities. Voters, although more sensitive to the location of the preferred candidate than to the location of his rival, are concerned with the nature of both potential winners.

From Eq. 3.7 and the results outlined above, we can see that the data consistently suggests that $(\bar{\alpha} + \varepsilon_i)\beta_1 < ((\bar{\alpha} + \varepsilon_i)\beta_2 + f)$ and hence either $\beta_2 > \beta_1$ or f is large. $\beta_2 > \beta_1$ would imply that the utility function itself was convex, whereas a large f with β_1 β_2 would imply strong ideological costs to participating for unsavory candidates, while maintaining a conventional, concave, utility function.

However, differentiating between these two scenarios is a complex task. Ideally, one would wish for a measure of the voter's *reluctance* to vote, to serve as a proxy for costs. No such term is available, however.

There are, however, some potential proxies for the agent's concern for the election's outcome (i.e. for the agent's political utility function). This binary variable, taken from answers to a series of questions concerning the voter's care for the issues at stake between the candidates, appears to be strongly proximity sensitive, as is seen in Table 10.

Table 10 Respondents' interest in the electoral outcome as a function of the voter's perception of relative candidate placement

carewin	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
preferred	.008559	.0003455	24.772	0.000	.0078817	.0092363
less-pref	-.0040107	.0002627	-15.269	0.000	-.0045256	-.0034957
constant	.1394951	.0283597	4.919	0.000	.0838992	.195091

It could be argued that this variable, *carewin*, is acting as a proxy for the whole decision to participate, incorporating the agent's utility function and costs. However, carewin is, on its own, an extremely weak predictor of participation (far weaker, for example, than the respondent's *intention* to vote).[41]

These results are replicated if the variable *interest* (representing the respondent's overall level of awareness of the campaign) is substituted for carewin. In either case, the respondents are more sensitive to the preferred candidate, even *prior* to considering the costs of participation.

While these results offer no evidence as to the structure of voters' costs, the fact that they suggest that, independent of costs, voters are already proximity-sensitive is

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[41] For example, while a sparse regression of participation on carewin generates an R^2 of only 3.4% (or 8.5% in conjunction with demographic terms), a sparse regression on the intention to vote results in an R^2 of 27.8% (or 30.5% with demographic terms).

significant on its own. Without having to make any assumptions as to the cost structure, a rational electoral participant with *proximity sensitive political utility* is intrinsically susceptible to alienation. Thus, any politician who intends to use strategic candidate placement to maximize his or her electoral chances must be aware not only that convergence and maneuver can win votes, but it can also lose them.

Section VI: Conclusions

The evidence presented in this paper represents a prototypical analysis of the empirical evidence for alienation in U.S. elections. The dataset from which it was drawn holds all of the disadvantages of a multi-purpose, interdisciplinary survey. However, by presenting the extremely rare data on actual participation, it allows at least some progress beyond the scope of abstract hypotheses.

Throughout the data, two consistent facts emerge. Firstly, political candidate placement issues are *not* the dominant determinant of participation rates. Far more entrenched personal and demographic characteristics are responsible for the majority of variation in turnout. However, candidate placement is within the politician's power to control, where the other factors are not. As one of the few available levers for a candidate to use to motivate the electorate, it is sufficient that placement is *a* key factor, without the need for it to dominant in itself.

Secondly, within the issue of candidate placement, the role of the preferred candidate is consistently more important than that of the less-preferred candidate. Although the separation of the candidates is, as we would expect, vital, even it does not remove the relative importance of the preferred politician's perceived position.

This result persists in the face of demographic characteristics, and under both a uni-dimensional scale for candidate placement and a proxy for an infinitely-dimensioned scale. Indeed, this consistency is more surprising than the result itself.

Furthermore, there is some evidence that this alienation is driven not by a myopic concentration on one candidate, nor by ideological costs alone, but rather that the agents' political utility functions are most sensitive to changes in candidate placement close to the agent's ideal, rather than being concave, and hence distance-sensitive. This behavior, on its own, is sufficient to make alienation not just a potential occurrence but rather a necessary consequence of candidate strategy.

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Appendix 1

Comparison of results from linear probability models and discrete choice models

As is described in the main body of the paper, the results presented there are from OLS regressions, even though, as we are dealing with a discrete choice model, Probit or Logit might seem more logical. The models were, however, re-run under Logit and Probit techniques, and entirely equivalent results were achieved. Presented below is the Logit-based version of Model G, as well as the Probit version of model G, and Model G itself.

It is immediately apparent that the patterns of significance are replicated across the models. Furthermore, using the ratios suggested by Maddala (1983), the second and third tables present the "corrected" coefficient estimates from all three models. As can clearly be seen, the OLS, Logit and Probit estimates are extremely similar in all cases.

Given that the models generated in this paper were all intended to capture a low but significant proportion of the motivation to participate, the risk of predicting greater than certain actions was avoided in all reasonable circumstances.

Table 11 Uncorrected coefficient estimates and standard errors from the OLS, Probit and Logit models of participation as a function of candidate placement, sex, race and income.

Term:	OLS		Probit		Logit	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Subopt02	-0.0017875	0.0004902	-0.0047789	0.0013297	-0.0077814	0.0021642
Sex	-0.0253495	0.0150971	-0.0718568	0.0413574	-0.1266352	0.0677986
Race	0.1655454	0.0205311	0.4306848	0.0551355	0.6937572	0.0886808
Income	3.870E-06	4.490E-07	0.0000111	1.300E-06	0.0000191	2.260E-06
Diff01	0.0013864	0.0003029	0.0038390	0.0008337	0.0063709	0.0013753
Constant	0.4172357	0.0280339	-0.2307121	0.0758883	-0.3862869	0.1231478

Table 12 Corrected coefficient estimates and standard errors from the OLS and Logit models

Term:	OLS		Coefficient size, relative to OLS	Logit		Coefficient size, relative to OLS
	Coefficient	S.E.		Coefficient	S.E.	
Subopt02	-0.0017875	0.0004902	100%	-0.00194535	0.00054105	109%
Sex	-0.0253495	0.0150971	100%	-0.03165880	0.01694965	125%
Race	0.1655454	0.0205311	100%	0.17343930	0.02217020	105%
Income	0.0000039	0.0000004	100%	0.00000478	0.00000057	123%
Diff01	0.0013864	0.0003029	100%	0.00159273	0.00034383	115%
Constant	0.4172357	0.0280339	100%	0.40342828	0.03078695	97%

Table 13 Corrected coefficient estimates and standard errors from the OLS and Probit models

Term:	OLS		Coefficient size, relative to OLS	Probit		Coefficient size, relative to OLS
	Coefficient	S.E.		Coefficient	S.E.	
Subopt02	-0.0017875	0.0004902	100%	-0.00191156	0.00053188	107%
Sex	-0.0253495	0.0150971	100%	-0.02874272	0.01654296	113%
Race	0.1655454	0.0205311	100%	0.17227392	0.02205420	104%
Income	0.0000039	0.0000004	100%	0.00000444	0.00000052	115%
Diff01	0.0013864	0.0003029	100%	0.00153560	0.00033348	111%
Constant	0.4172357	0.0280339	100%	0.40771516	0.03035532	98%

Note: Correction mechanism (as per Maddala (1983) and others): The OLS coefficients are considered the baseline to which the Logit and Probit estimates must be "merged". To generate equivalent Logit estimates, multiply the Logit coefficients by .25 (or, in the case of the constant, multiply by .25 and add .5). To generate equivalent Probit estimates, multiply the Probit coefficients by .40 (or, in the case of the constant, multiply by .40 and add .5).

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