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Majority Voting: A Quantitative Investigation

by Daniel R. Carroll, Jim Dolmas, and Eric R. Young

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We study the tax systems that arise in a once-and-for-all majority voting equilibrium embedded within a macroeconomic model of inequality. We find that majority voting delivers (i) a small set of outcomes, (ii) zero labor income taxation, and (iii) nearly zero transfers. We find that majority voting, contrary to the literature developed in models without idiosyncratic risk, is quite powerful at restricting outcomes; however, it also delivers predictions inconsistent with observed tax systems.

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1 Introduction

Tax systems across the world are quite diverse, not only in terms of the overall level of tax rates but also in terms of the mix of tax systems. Carey and Rabesona (2002) document a range of tax systems from OECD countries, which we plot here in Figure (1); tax systems range from low (South Korea) to high (Norway) in terms of overall levels, and also vary substantially in terms of the mix between consumption, labor income, and capital income rates. The range of tax rates are $[0.064, 25.7]$ for consumption, $[0.099, 49.6]$ for labor income, and $[0.129, 39.5]$ for capital income. There is little correlation between the rates within a country as well. Similar diversity appears in the data constructed by Mendoza, Razin, and Tesar (1994) and Trabandt and Uhlig (2011).

A natural question to ask is how these tax systems arose. Capital income taxes, for example, are often viewed as inefficient (Atkeson, Chari, and Kehoe 1999 survey these arguments), although that result is fragile in the presence of incomplete insurance and redistributive motives (see Golosov, Kocherlakota, and Tsyvinski 2003, Chien and Lee 2006, Conesa, Kitao, and Krueger 2008, and Straub and Werning 2014 for examples where capital income taxation is optimal); in contrast, consumption taxes are generally viewed as an efficient revenue source. Obviously the welfare calculations are conditional on the social welfare function used, and that Arrow's impossibility theorem renders economic discussion of the "right" welfare function meaningless; the natural question to ask is what happens when the policy is chosen according to majority voting?

Our goal in this paper is to take a small step toward studying the determinants of tax systems in macroeconomic models, using tools from political economy. In particular, we will use solution concepts for majority voting in multiple dimensions to study what kinds of tax systems could arise in a once-and-for-all vote, with voters understanding the transitional and long-run consequences of particular tax systems. In general, Condorcet winners in more than one dimension exist only under extreme symmetry conditions (called Plott symmetry after Plott 1967); unfortunately, in our model preferences over taxes are derived from primitive preferences over consumption and leisure and cannot simply be assumed to possess the necessary symmetry.[1] We therefore turn to generalizations of majority voting solutions that permit multiple winners.

However, we do not want to simply "give up" and assume that anything goes; our goal after

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[1]We do not attempt to find sufficient conditions for Plott symmetry in our model. Given that we can only solve the model numerically, it seems impossible to make any progress along this line.

all is to decide what tax systems are feasible under majority voting. Therefore, we use the most restrictive of the solution concepts that we could find in the literature, the essential set from Dutta and Laslier (1999). The essential set is given by the strictly positive support of strategies played in some mixed strategy Nash equilibrium of the voting game. This set is contained within the uncovered set from McKelvey (1986), which contains the strategies that would survive under agenda setting and sophisticated voting (that is, what strategies could be implemented if we selected different orderings for pairwise competition), and so has a convenient interpretation as those strategies that could win depending on which agent controls the voting agenda. If the uncovered set is a singleton (and therefore so is the essential set), then the unique element is the Condorcet winner.[2]

We have three main results from these experiments.

Our first result is that majority voting in our model is quite powerful – we find a Condorcet winner for a very fine grid of policies. This result stands in contrast to Dolmas (2008), and arises because we have many "types" of voters (with correspondingly low measure) which makes it difficult to construct winning coalitions.[3] Thus, the idea that "anything can happen" with majority rule is not true in our model; specifically the range of tax systems observed in the data cannot be reconciled with homogeneous countries choosing among different majority voting outcomes.[4]

Our second result is that labor income taxation is unpopular – the Condorcet winner sets the labor tax to zero. This result arises because the majority of agents in the economy have labor income and do not want to tax it; with once-and-for-all voting, agents who currently do not have substantial labor income (either because they are unproductive or because they are

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[2]Miller (2007) contains an extensive discussion of the uncovered set in a special case of a two-dimensional game with "Euclidean" (circular) preferences. It turns out our model, under a change of variables, will look quite Euclidean, so much of his discussion may apply (with appropriate adjustment to three dimensions). However, our agents have preferred points that are often on the boundary of the policy space, which has uncertain consequences for his results.

[3]Types are differentiated by their preferred tax systems; thus, many households who look different may be considered the same type.

[4]For example, if there are many possible outcomes then the individual who controls the agenda will have an influence on the selected policy. Since agents are generally not indifferent between policies in the uncovered set, agenda control has value.

wealthy) expect to have more in the future and do not want to commit to taxing it, and obviously those currently with high labor income do not want to tax it either. Interestingly, consumption taxes are used; unlike representative agent models, consumption and labor income taxes are not equivalent because the rich consume but do not work. Consumption taxes work like a tax on initial wealth; since wealth is very persistent in the model, the majority is more willing to tax it.

Our third result is that lump-sum transfers are very close to (and possibly actually equal to) zero in the terminal steady state (we do not permit lump-sum taxation). Despite substantial market incompleteness, households do not implement tax systems that raise revenue above that needed for wasteful government spending; again, mobility implies that households expect to contribute more than they receive (on average), and thus want to avoid committing themselves to positive transfer systems. This result stands in opposition to models without mobility, such as Dolmas (2008) or Krusell and Ríos-Rull (1999), where transfers can be substantial. Our model actually overstates slightly the amount of mobility over five-year horizons, but the support for the very small transfer is strong enough that a closer fit would be unlikely to change the result. The high degree of patience needed to generate reasonable wealth-income ratios also contributes to the low transfer; when we let households vote "myopically" they choose a higher transfer financed through high taxes.

Obviously our experiments have limitations. Our policy space is restricted heavily, for feasibility reasons – we assume that households vote over constant tax systems only, and they vote only once. Given the small changes in inequality that result from changing the tax system and the strong support the Condorcet winner enjoys, it seems likely that the once-and-for-all part is not restrictive, but the assumption of constant taxes is likely to be; Dyrda and Pedroni (2014), in a study of optimal tax systems in the Aiyagari (1994) environment, find substantial variation in labor and capital taxation over the transition (capital taxes fall and labor taxes rise).[5] It may be feasible to use the method of Dyrda and Pedroni (2014) – they parametrize the path of taxes and optimize over the parameters – but not without substantial increases in computational costs (which are already rather heavy).

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[5]Dolmas (2008) uses a model with no transitional dynamics, and so circumvents this problem entirely.

1.1 Related Literature

We have already mentioned the paper most closely related to this one, Dolmas (2008). As noted above, Dolmas (2008) finds that majority voting is not a powerful tool for making predictions. Other papers that study the politics of multidimensional tax systems, such as Krusell, Quadrini, and Ríos-Rull (1996), set up their models to have a single decisive type whose identity is known, avoiding the problems that arise in our model but also limiting the extent to which the model can match the inequality data; we note that the low degree of heterogeneity assumed in Dolmas (2008) is the source of his weak predictions.

DeDonder (2000) also studies tax system determination using multi-valued solution concepts and finds, as we do, that the uncovered set is small (although he does not have a Condorcet winner in general). However, his model is static, so capital income taxation is not distortionary, and his parameters are not calibrated to match any cross-sectional facts. In contrast, our model is fully dynamic and we are explicit about the connection between our parameters and U.S. data.

One other paper closely related to ours is Corbae, D'Erasmo, and Kuruşçu (2009), who study how a median voter would select an income tax/lump-sum transfer system. Using the median voter theorem they are guaranteed to get a unique outcome in each period, and therefore are able to study equilibria without commitment to constant taxes. They find that the median voter responds to rising wage variance by increasing the income tax and transfer substantially; our results suggest that, given enough tools, the majority of voters might respond in quite a different manner.[6]

There are a number of other papers that study political outcomes in the growth model. Rather than exhaustively list them here, we just note that our paper seems to be the only one that combines multi-dimensional voting with mobility and non-trivial decisive voter types.

2 Model

The model economy is populated by a continuum of *ex ante* identical households as in Aiyagari (1994). Each household receives an uninsurable shock ε to their wages in each period, which

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[6]Aiyagari and Peled (1995) also study voting equilibria in a model of idiosyncratic risk, but they assume the economy instantly transits to the terminal steady state.

follows the process

$$\log\left(\varepsilon'\right) = \rho\log\left(\varepsilon\right) + \sigma\eta'.$$

Preferences are represented recursively as

$$v\left(k,\varepsilon\right) = \max_{c,h,k'}\left\{\log\left(c\right) + \theta\log\left(1-h\right) + \beta E\left[v\left(k',\varepsilon'\right)|\varepsilon\right]\right\}$$

subject to nonnegativity constraints and the budget constraint

$$\left(1+\tau_c\right)c + k' \leq \left(1 + \left(1-\tau_k\right)\left(r-\delta\right)\right)k + \left(1-\tau_l\right)w\varepsilon h + T.$$

Here, c is consumption, k is the current holdings of assets, h is labor effort, r is the rental rate on capital, and w is the wage per efficiency unit of labor. The taxes are on consumption τ_c, labor income τ_l, and capital income τ_k, with lump-sum nonnegative transfer T.

The production sector consists of a single firm that operates the technology

$$Y = ZK^\alpha N^{1-\alpha}$$

where Z is productivity, K is the aggregate capital stock, and N is aggregate labor input.[7] The optimal factor demands implicitly satisfy the equations

$$r = \alpha Z\left(\frac{K}{N}\right)^{\alpha-1}$$

$$w = \left(1-\alpha\right)Z\left(\frac{K}{N}\right)^{\alpha}.$$

The government budget constraint is

$$G + T = \tau_c C + \tau_l wN + \tau_k\left(r-\delta\right)K,$$

where G is wasteful government spending. We abstract from government debt for computational reasons (three dimensions is already pushing what we can solve easily).

Markets clear if

$$K = \int_k\int_\varepsilon k\Gamma\left(k,\varepsilon\right)$$

$$N = \int_k\int_\varepsilon \varepsilon h\left(k,\varepsilon\right)\Gamma\left(k,\varepsilon\right)$$

$$C = \int_k\int_\varepsilon c\left(k,\varepsilon\right)\Gamma\left(k,\varepsilon\right)$$

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[7]Z facilitates calibration, but otherwise merely serves to normalize units.

and

$$C + K' - (1 - \delta) K + G = Y.$$

3 Calibration

We choose the parameters of our model to match some facts about the US economy. Specifically, we target a capital/output ratio of 12, a government/output ratio of 0.2, an investment/output ratio of 0.15, aggregate hours equal to 0.3, and capital's share of income equal to 0.36, along with a steady state output level of $Y = 1$. Combined with the US tax system of $(\tau_c, \tau_l, \tau_k) = (0.064, 0.234, 0.273)$ we obtain a transfer equal to 9.1 percent of GDP, quite close to the actual value. Table (1) presents the structural parameters that give rise to this calibration.

We set $\rho = 0.978$ and $\sigma = 0.0516$, consistent with the values from Flodén and Lindé (2001). Thus, wage shocks are very persistent and volatile.

Our model matches reasonably well to the inequality and mobility observed in US data, but not perfectly. Figures (2) and (3) present the Lorenz curves for earnings and wealth in the US and in the model; while we do not get enough concentration in either we do relatively well. Furthermore, since our main deviation is in the very rich, who have little mass, under majority voting their presence will not matter. Tables (2) and (3) show mobility statistics from the model and the data; again, we do surprisingly well, with clear deficiencies only in the extreme quintiles whose preferences are unlikely to matter given the strong majorities we find.

In our results we assume equal-weighted voting. If we consider the possibility of heterogeneous participation/campaign contributions (as in Bachmann and Bai 2013), the absence of the super-rich would clearly matter as these individuals vote at high rates and contribute more to political campaigns, meaning they likely have higher "effective voting power". We will point out exactly where wealth-weighted voting schemes are likely to change our results.

4 Majority Voting

Our main experiment is to consider what tax systems a majority voting system would select. Here, we call a tax system a vector $\tau = (\tau_c, \tau_l, \tau_k)$ along with a sequence of transfers $\{T_t\}_{t=0}^{\infty}$ that satisfy the government budget constraint period by period. We discretize the policy space, and

solve for the transition to each of the possible values.[8] We restrict the policy space to those tax systems that do not require lump-sum taxation in any period t, including the terminal steady state, so that $T_t \geq 0$ must hold. We also do not permit negative tax rates.[9]

We define the payoff function

$$V\left(\tau; k, e\right) = v\left(k, e; \tau\right).$$

Note that we think of the payoff function as depending on taxes with (k, e) as parameters, in contrast to the lifetime utility function v which reverses these variables. We can then define the preference relation $\mathcal{P}(k, e)$ by

$$\tau_i \mathcal{P}\left(k, e\right) \tau_j \Leftrightarrow V\left(\tau_i; k, e\right) \geq V\left(\tau_j; k, e\right).$$

Ties are unlikely in our model due to numerical approximation, so we simply ignore them. It is a straightforward use of the Theorem of the Maximum to obtain that V is continuous in τ, and we can confirm numerically that V is also concave in τ. These properties are needed to argue that the solution concepts we apply have appealing properties.

With more than one dimension in the policy space, the median voter theorem generally does not apply. As a result, there may not exist a Condorcet winner, so we use a concept from political economy called the **essential set** as our solution concept (see Dutta and Laslier 1999); the essential set is the set of all policies played with positive probability in some mixed strategy Nash equilibrium.[10] To compute this set, we first note that it lies within a pair of other sets, called the Pareto set and the uncovered set, which pares down the number of potential policies substantially; we give formal definitions of these sets in the Appendix. Let s_i denote the probability assigned to policy vector i, drawn from a set with $N < \infty$ possible policies. We then solve the linear

[8]We use an irregular sparse grid that we solve the transitions on, and then we use a three-dimensional quadratic Shepherd's method to interpolate the value functions and the transfer function to other points. The irregular grid is concentrated in the region around the Condorcet winner and along the zero transfer/zero labor tax locus.

[9]Both assumptions are restrictive, as both transfers and labor income are very close to zero in the Condorcet winner.

[10]The essential set is a generalization of the **bipartisan set** from Laffond, Laslier, and Le Breton (1993); the bipartisan set is the mixed strategy support when the mixed strategy equilibrium is unique, whereas the essential set is the union of the strategy support for all mixed strategy equilibria. See Dutta and Laslier (1999) for discussion.

program

$$(s^*, \varepsilon^*) = \underset{\varepsilon, \{s_1, ..., s_N\}}{\operatorname{argmax}} \{\varepsilon\}$$

subject to

$$\sum_{j=1}^{N} d_{i,j} s_j \leq 0 \quad \forall i \in \{1, ..., N\}$$

$$s_i - \sum_{j=1}^{N} d_{i,j} s_j - \varepsilon \geq 0 \quad \forall i \in \{1, ..., N\}$$

$$\sum_{i=1}^{N} s_i = 1$$

$$s_i \geq 0 \quad \forall i \in \{1, ..., N\}$$

$$\varepsilon \geq 0.$$

The essential set then consists of the tax policies that are played with strictly positive probability:

$$E = \{\tau_i : s_i^* > 0\}.$$

The $d_{i,j}$ terms come from the **dominance matrix**, defined as

$$d_{i,j} = \begin{cases} 1 & \text{if } i \neq j \text{ and } \int_k \int_e \mathbf{1} \left(\tau_i \mathcal{P}(k,e) \tau_j\right) \Gamma_0(k,e) > \frac{1}{2} \\ 0 & \text{if } i = j \\ -1 & \text{if } i \neq j \text{ and } \int_k \int_e \mathbf{1} \left(\tau_i \mathcal{P}(k,e) \tau_j\right) \Gamma_0(k,e) < \frac{1}{2} \end{cases},$$

where $\Gamma_0(k,e)$ is the initial distribution. If there is a Condorcet winner, it will be the only member of the essential set.[11].

5 Experiment

In period $t = 0$, taxes are fixed at $\tau^{initial} = (0.064, 0.234, 0.273)$. A majority vote decides a permanent change in taxes which will be imposed beginning in period $t = 1$. The evaluation of these new taxes includes the costs of the transition to the terminal steady state.

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[11]The linear program is discussed in Brandt and Fischer (2008)

5.1 Global Results on a Coarse Grid

We begin by discretizing the policy space. In order to allow for a wide range of policies, we make the intervals in each dimension large. Specifically, we construct a coarse grid of 1600 candidate policies formed from combinations of (τ_c, τ_l, τ_k) with $\tau_c \in \{0, 0.1, 0.2, ..., 1.8, 1.9\}$, $\tau_l \in \{0, 0.1, 0.2, ..., 0.9\}$, and $\tau_k \in \{0, 0.1, 0.2, ..., 0.7\}$. Next, we solve for the terminal steady state for each candidate. Any candidate that leads to a negative lump-sum transfer in the final steady state is removed from the policy space.

For each of the remaining candidates, we solve for the transition path from the initial distribution with $(\tau_c, \tau_l, \tau_k) = (0.064, 0.234, 0.273)$ to the final steady state. If transfers are negative anywhere along the transition, the candidate is removed from the policy space. We use the value functions from the remaining policies to conduct the majority vote. We find a Condorcet winner on the coarse grid at $\tau^{Cond} = (0.20, 0.00, 0.30)$ and use this point to illustrate tax preferences over the entire space. By comparing the value functions resulting from adopting different tax policies (and going through the resulting transition path), it becomes evident which parts of the (k, ε)-distribution support various tax configurations.[12]

It is interesting to see that the results of Dolmas (2008) do not carry over to our environment here – in that paper, the essential set was large relative to observed tax systems, suggesting that majority voting theory could not meaningfully restrict outcomes.[13] We demonstrate in an Appendix that the reason Dolmas (2008) gets such weak results is that he has a small number of types that are permanent and thus have very different views about desirable taxes; our model here has both a large number of types and lots of mobility, so that agents who have to precommit to future taxes will be (i) reluctant to advocate for very high taxes since they expect to have to pay them in the future, unlike a world without mobility; and (ii) the number of coalitions that can achieve a majority is small relative to the number of types (because types are relatively small in mass), whereas in Dolmas (2008) the number of different majority coalitions is relatively large.

We will plot the difference (measured in utils) between the value function, v^{Cond}, from switch-

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[12]If we confine policies to those observed in the OECD data plotted in Figure (1), we find that South Korea is the Condorcet winner; it has the lowest labor income taxes in the group by a large margin (9.9 percent as compared to the next lowest of 22.6 in the United Kingdom).

[13]Dolmas (2014) shows that two common implementations of probabilistic voting deliver orthogonal tax systems, further demonstrating the predictive impotence of majority voting outcomes.

ing to τ^{Cond}, and that from switching to an alternative policy, v^{alt}. An alternative policy is selected so that it differs from τ^{Cond} in only one dimension. In this way, we can see how households view increases in one type of tax holding the other two types fixed. If $v^{Cond}(k,\varepsilon) - v^{alt}(k,\varepsilon) > 0$ (< 0), then households at (k,ε) in the initial distribution would vote for (against) τ^{Cond} in a pairwise competition with τ^{alt}. We examine only policies with rates higher than the Condorcet winner; since we are far from the peak of the Laffer curve and transfers are nearly zero it is not possible to finance G with lower rates.

5.1.1   Consumption taxes

Figures (4) - (6) plot the value function difference for increasing levels of consumption taxes. In all of the figures, the welfare gain (util difference) is increasing in k. This result makes sense when one considers that an increased consumption tax is equivalent to a tax on initial wealth. For households supplying positive work hours, a consumption tax is also equivalent to a labor tax, and support for higher consumption taxes therefore naturally decreases in ε.

Notice that the welfare gain curves converge as k increases and that of low ε types merge at lower k levels, due to the substitution effect on hours. As k increases the wealth effect on leisure pushes households to the corner of their hours decision, and the least productive households are the first to exit the labor market. Figure (7) plots the hours decisions under the coarse grid Condorcet winner.

For households not supplying labor, the consumption tax/labor income tax equivalence only matters due to the likelihood that the household re-enters the labor market in the future, and this likelihood depends upon the persistence of the ε process. Consider a household with $\varepsilon = \varepsilon_{\min}$ and enough wealth so that the household does not work. First, the household will consume more than its after-tax capital income so it will have less wealth next period. Second, because productivity shocks are serially correlated, the household is most likely to draw another low ε tomorrow, causing it to decrease its wealth further and moving it closer to a k level where it works. Finally, because higher productivity households exit the labor market at higher wealth levels, as the household reduces its wealth the probability that it will supply positive hours due to a favorable ε shock rises.

Moving from a 20 percent to a 30 percent consumption tax is rejected by all higher than

median-ε households and by all households with k above 18. At 0 wealth, the median-ε household favors increasing the consumption tax rate, but as the competing consumption tax rate increases, the wealth level at which all household productivity types vote against the alternative policy declines. When the candidate τ_c is 60 percent, the threshold is 13.5. In addition, median ε type households universally support the Condorcet winner. For the lowest two productivity type households the welfare gain is less than it is for $\tau_c = 0.3$, meaning that a 60 percent consumption tax is closer to these households' ideal policy. There is a humped shape to policy preferences however. At $\tau_c = 120$ percent, only $\varepsilon_{\min}$ households with very low wealth still favor the alternative policy to the Condorcet winner, and the welfare gain is not as negative as it was for $\tau_c = 0.6$.

Voting shares reflect the humped shape of tax preferences. Figure (8) plots the fraction of households voting against the Condorcet winner for alternatives with higher consumption tax rates. Support for the alternative declines monotonically as τ_c increases and decreases sharply between 40 percent and 50 percent. The Condorcet winner has a comfortable majority even against $\tau_c = 0.3$, with over 61 percent of the vote.

5.1.2 Capital income taxes

Figures (9) - (11) plot the welfare gains associated with varying the capital income tax. Support for increasing capital taxes falls in k and in ε. Declining support in k is obvious, but not necessarily so for ε. Why does every low wealth household vote against 70 percent capital income taxes? There are two reasons. First, these households get nearly all of their income from labor so the wage matters a lot to them. High capital income taxes reduce the capital-labor ratio, driving down the wage. The effect of a wage decline on labor income is most pronounced for households with high productivity. Second, there is a lot of mobility in the model, meaning that households transition through the wealth distribution quickly relative to their discount factor. Simply put, even zero wealth households expect to have a lot more wealth in the "near" future, and so they share much of the same disfavor for capital income taxes as their currently rich counterparts. At 50 percent, capital income taxes are to the right of even what most low ε, zero wealth households would prefer. At 70 percent, the Condorcet winner wins unanimously. Figure (12) shows the same monotonic decline in support as policy moves away from the Condorcet winner in the capital income tax direction. The vote share is especially sensitive in this dimension.

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5.1.3 Labor income taxes

The model predicts zero labor income taxes.[14] Preferences for increasing labor income taxes are monotonic decreasing in ε. Households that are more productive dislike labor taxes more, especially at low wealth levels where labor income is most important for consumption. However, labor income tax preferences over k are not monotonic. Instead each ε-curve is U-shaped over k and divided into three regions (see Figures (13)-(15)).

In the first region, households have low wealth and support low labor income taxes. As households gain wealth, they reduce their dislike of labor income taxes with low ε households being the first to move into the second region and vote for increasing the tax. The downward slope is once again due to the wealth effect on hours. Each ε-type curve bottoms after the wealth level where it stops working. Notice the same merging of curves from the bottom first, as the corner is hit at higher wealth levels for higher ε due to the substitution effect.

The reason for that households eventually switch back to preferring lower labor income taxes is the effect on the interest rate. Sufficiently-rich households do not work and do not expect to work for a long time. The income and consumption of these types depend entirely upon the return to capital. Labor income taxes increase the capital-labor ratio and reduce r, so rich households oppose them. The fraction of households in the second and third regions is small, however, so the outcomes are primarily determined by the first region. As Figure (16) illustrates, even a deviation as small as 10 percent from zero labor income taxation is opposed by over 78 percent so the Condorcet winner would pass the common supermajority requirement of 67 percent.[15]

5.2 Fine Grid

In a second voting experiment, we restrict the policy space to a neighborhood around the global Condorcet winner and refine the step sizes between candidates to 1 percent. This level of fineness was not possible in the global experiment because the number of policy options became unmanageable. Since preferences across tax policy exhibit the key Euclidean property (falling

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[14]Although we do not permit labor subsidies, it is likely that a policy with negative labor income taxes would defeat the Condorcet winner here. Azzimonti, de Francisco, and Krusell (2009) also find majority support for labor subsidies, but in a very different environment.

[15]Caplin and Nalebuff (1988) show that a "mean voter theorem" implies a 64 percent rule for majority voting, close to the standard supermajority requirements used in the U.S.

off with distance from an ideal point, or single-peakedness), it seems likely that a Condorcet winner over this refined set would beat any candidate policies from the coarse grid set as well. We check this and find that it is so. At the 1 percent level, the new Condorcet winner is $\tau^{Cond} = [0.16, 0.00, 0.19]$. Most notably, this policy features considerably lower consumption income taxation than did the Condorcet winner on the coarse space. The is because the two nearest points to τ^{Cond} on the coarse grid, $[0.20, 0.00, 0.10]$ and $[0.10, 0.00, 0.20]$, violate the non-negativity constraint on transfers. τ^{Cond} pushes up against this constraint as transfers come very close to zero along the transition.

Combining results from the fine grid and the coarse grid cases allows us to plot the most preferred (τ_c, τ_l, τ_k) of a given ε type at different wealth levels. Figures (17) - (19) do this for the lowest productivity, the median productivity, and the highest productivity households. For the lowest productivity households, the most preferred tax combination is high consumption taxes, moderate capital income taxes, and zero labor income taxes. As wealth increases the preferred combination switches to zero consumption taxes, high labor income taxes, and slightly lower capital income taxes. The switch occurs around the wealth level at which the household earns a large fraction of its income from capital. The picture is generally the same for all ε types. At low levels of k, consumption taxes are preferred to labor taxes with capital income somewhere in between. Then at a higher level of wealth the ordering switches so labor income taxes become preferred to consumption taxes. The differences across types are mainly the degree to which they wish to tax consumption when at low k levels. The least productive wealth-poor want very high consumption taxes while their most productive counterparts want moderate levels. The k level at which the preferences switch increases with ε since the substitution effect on hours is stronger, keeping high ε types working more, and thus more exposed to labor income taxation.

In Figure (20) we add the cumulative distribution of wealth into the plot, so that it is apparent why labor income taxes are opposed by the majority voting system – essentially no households reach the wealth levels where they become preferred. Here is where we believe wealth-weighted voting will make a difference – the sharp changes in the preferred labor income tax rate at wealth levels near the top of the distribution would matter more if those individuals had voting power proportional to their wealth and not their measure. Given that calibrating the reweighting scheme is difficult, we postpone this issue for now.

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5.2.1 Transition Path

Figures (21) - (23) plot the transition paths of economy aggregates resulting from a change to the fine grid Condorcet winner. While aggregate activity is higher in the long-run, there is a decline in most aggregates in the very early periods of transition. The capital stock falls to 1.2 percent below initial steady state level. Overtime it rises reaching a level 17.8 percent higher at the end of the transition. Effective labor input, hours, consumption, and output all fall sharply initially and rise above their initial levels. Despite considerable initial wealth and income inequality, majority voting in the model does not lead to much redistribution in the long run. The transfer falls sharply from over 9 percent of GDP to nearly 0 and remains there for the entire transition.[16]

5.2.2 Inequality

The Condorcet winner on the coarse grid gives rise to a long run wealth distribution with more inequality than the initial distribution. This can be seen from the cumulative distribution function plotted in Figure (24). The cdf for the coarse grid Condorcet winner rotates at roughly 25 percent of initial mean wealth, indicating compression at low wealth. Meanwhile, the cdf approaches 1 more slowly than the initial cdf indicating a more skewed right tail[17]. However, the changes are small. We interpret these small changes as evidence that our assumption of a once-and-for-all vote is unlikely to be restrictive; the agents will be in nearly the same distribution in each time period and therefore will not generate substantial support for alternative policies (particularly since the Condorcet winner enjoys very strong support).

Because there are mixed effects on inequality from changing the various tax rates, we once again compare the coarse grid Condorcet winner to alternative policies which isolate tax changes along a single dimension. Figure (25) plots the cdfs of the steady state wealth distributions for alternative policies with much higher consumption taxes. As τ_c rises, long run inequality is unambiguously reduced, which is the wealth tax equivalence of consumption taxation appearing again since higher consumption taxes redistribute initial wealth. Figure (26) plots cdfs for changes in capital income taxes. Just like consumption taxes, capital income taxes also unambiguously

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[16]Experimenting with capital adjustment costs led to no meaningful changes in the long-run outcomes, only a correspondingly slower transition.

[17]Both the coarse grid winner and the fine grid winner first-order stochastically dominate the initial distribution.

decrease long run wealth inequality. Labor income taxes have a very small effect on the lower end of the wealth distribution, increasing inequality just slightly. At the middle and upper ends, however, labor income taxes have much stronger inequality-reducing effects. The cdfs are plotted in Figure (27).

5.2.3 The Role of Mobility and Patience

Our results depend critically on two aspects of our economy – households are mobile (they move around the (k, ε) space) and they are very patient. We explore the role of mobility by studying a version of our economy in which ε is fixed at the current value; as noted by Krusell and Ríos-Rull (1999) and Chatterjee (1994), the resulting economy has no mobility. What we find is that the level of transfers is substantially higher, along with the levels of capital and consumption taxation, but labor income taxes remain zero. Mobility matters because agents expect to be "average" in the future; combined with a high β they become reluctant to impose high taxes since they are committed to them for all time. Tables (2) and (3) show that our model actually overstates mobility for certain groups (based on mobility measures from Budría *et al.* 2002), namely the very wealthy and very poor; with less mobility we would find that support for higher transfers would increase, although given the strong majority enjoyed by the Condorcet winner it seems unlikely that it would rise enough to rationalize the US level.

To examine the role of patience we consider a case where households evaluate the transition for the purposes of voting using a discount factor $\beta^* < \beta$; we call this "myopic voting". That is, households make economic decisions using

$$v_t (k, e; \tau) = \log (c_t (k, e)) + \theta \log (1 - h_t (k, e)) + \beta E \left[v_{t+1} \left(k_{t+1} (k, e), e'; \tau \right) | e \right]$$

but vote using

$$\widetilde{v}_t (k, e; \tau) = \log (c_t (k, e)) + \theta \log (1 - h_t (k, e)) + \beta^* E \left[\widetilde{v}_{t+1} \left(k_{t+1} (k, e), e'; \tau \right) | e \right].$$

We find that the transfer again rises substantially, and both capital and consumption taxation increase. The reason is that now the future is discounted more, meaning that the currently "poor" are less affected by their transition to being average in the future. Depending on the degree of myopia in voting, we can generate very large transfers as a Condorcet winner, although

there is little discipline we can bring to bear on this parameter beyond matching the transfers in some country. Details of these experiments are available upon request.[18]

6   Conclusion

We found that majority voting is quite powerful even in many dimensions in the model of Aiyagari (1994). However, our model produces outcomes that lie outside the range of tax systems in the data, even those these systems are quite heterogeneous; in particular, we find very low transfers and very low labor income taxes relative to any observed country. We find these results despite using an environment in which government intervention can improve allocations (see Dávila *et al.* 2012). Extensions to include permanent differences in labor productivity could bring the predictions more in line with the data, and we are investigating them currently, along with other sources of heterogeneity (such as age).

The machinery developed here can be extended in a number of ways. Of particular interest to us would be to study the politics of progressive taxation, extending the results of Carroll (2011) in a number of directions. The tax function commonly used in macroeconomic models, taken from Gouveia and Strauss (1994), has three parameters that govern (roughly) the maximum tax rate, the progressivity of taxes, and the income exemption level; we are adapting our model to examine how majority voting would select that function.[19].

Another application of our toolkit is to study the design of social insurance schemes. In the U.S., unemployment insurance is relatively stingy but bankruptcy rules are generous, while in Europe the opposite is true. Athreya and Simpson (2006) document the welfare effects of bankruptcy rules and UI, finding that one can provide effective social insurance in either way but one should not have both be generous. It would be interesting to see whether majority voting could account for the choices using the observed differences in wage and wealth distributions. We could also investigate targeted transfers more broadly – it may be that while lump-sum transfers are not popular, transfers that go to specific groups can gain more support.

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[18]If we again restrict attention to the OECD country tax systems, the myopic voters select Norway instead of South Korea.

[19]The diversity of progressive tax systems in the data is documented by Holter, Krueger, and Stepanchuk (2014)

7 Appendix I

Here we define the Pareto and uncovered sets; we denote these sets by P and U, and the essential set by E, and note that

$$E \subset U \subset P.$$

Because solving the linear program that determines E is computationally infeasible with a large policy space, we use P and U to eliminate many options before computing E. If a Condorcet winner exists, it will be the unique element of U and therefore also E. As noted in the text, the set U is of interest because it contains policies that can survive under agenda setting with finite rounds.

Define the preference relation $\mathcal{P}(k, e)$ as

$$\tau_i \mathcal{P}(k, e)\, \tau_j \iff V(\tau_i; k, e) \geq V(\tau_j; k, e).$$

That is, $\mathcal{P}(k, e)$ identifies whether a type (k, e) prefers tax system i or j. The Pareto set is defined as all tax systems that are not defeated unanimously by any other system. That is,

$$P = \left\{ \tau_i : \int_k \int_e \mathbf{1}\left(\tau_i \mathcal{P}(k, e)\, \tau_j\right) \Gamma_0(k, e) < 1 \text{ for every } \tau_j \right\}.$$

In practice, due to the very small measure of some types, we compute an "approximate Pareto set" where we set the criterion that the policy is not defeated by a vote of at least 0.9999. The approximate Pareto set is contains a relatively small section of the policy space.

Next, we say that τ_i covers τ_j if

$$\int_k \int_e \mathbf{1}\left(\tau_i \mathcal{P}(k, e)\, \tau_j\right) \Gamma_0(k, e) > \frac{1}{2}$$

and

$$\int_k \int_e \mathbf{1}\left(\tau_i \mathcal{P}(k, e)\, \tau_q\right) \Gamma_0(k, e) > \frac{1}{2}$$

for all τ_q such that

$$\int_k \int_e \mathbf{1}\left(\tau_j \mathcal{P}(k, e)\, \tau_q\right) \Gamma_0(k, e) > \frac{1}{2}.$$

That is, τ_i covers τ_j if it beats j and it beats everything that j beats. The uncovered set is then the set of systems that are not covered:

$$U = \left\{ \tau_i : \nexists \tau_j \text{ such that } \tau_j \text{ covers } \tau_i \right\}.$$

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To compute the uncovered set, we construct the adjacency matrix M with (i, j) element

$$
m_{i,j} = \begin{cases} 1 & \text{if } i \neq j \text{ and } \int_k \int_e \mathbf{1}\left(\tau_i \mathcal{P}\left(k, e\right) \tau_j\right) \Gamma_0\left(k, e\right) > \frac{1}{2} \\ 0 & \text{otherwise} \end{cases}.
$$

Then compute

$$
M^* = M^2 + M + I;
$$

if $m_{i,j}^* = 0$ then i is covered by j. The uncovered set contains the policies that will survive under agenda setting with sophisticated voting. A Condorcet winner is obviously uncovered, and in fact is the unique element of U. If we continue this process we obtain the ultimately uncovered set U^* (see Dutta 1988); if U^0 is the uncovered set, then we can look for members of the uncovered set that are now covered given that some alternatives have been eliminated.

The essential set lies inside the uncovered set. We therefore solve the linear program only considering the tax policies in U, which keeps the size of the program manageable. Given that we found a singleton member of U, the linear program is trivial.

8   Appendix II

In this Appendix we discuss how our results relate to Dolmas (2008). In that paper, majority voting was found to have limited predictive power – the uncovered set and the essential set both contained a relatively-large number of policies that were "spread out" across the policy space. We illustrate that this limited power was a result of one crucial assumption, namely that the number of distinct types was small. We also discuss why Dolmas (2008) finds large transfers and we find small ones; that result comes from a lack of mobility in the income-wealth distribution.

The model of Dolmas (2008) is substantially different than ours, so we quickly describe the relevant ingredients. Households are endowed with an initial wealth k_0 and productivity e_0; unlike here, these values will remain fixed over time (in the case of wealth, fixed relative to the aggregate to be more precise). He supposes there are two values for each, leading to four types, and calibrates their weights to roughly match some distributional facts from the US. The result is that no group is a majority, but each has substantial measure; in fact, one can assemble a majority in his model in eight different ways, most but not all of which include the 'low e, low k' type that has measure just smaller than 0.5. Each of these types has very different preferred tax rates,

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which depend on where their primary source of income arises and how wealthy they are relative to the mean; however, most types are poorer than average so they desire positive transfers, and because there is no mobility they are not reluctant to impose high taxes to get them. Figure Figure (28) presents the uncovered set from Dolmas (2008) for his benchmark model with four types; note that the range of taxes is very large in each dimension. As a comparison we also present in Figure (28) the uncovered set when the number of types is extended to nine, using a similar calibration procedure that picks points from the Lorenz curves for earnings and wealth in the US; now the uncovered set has shrunk to a small number of points (6) and is confined to a region of zero labor income taxes, high capital and consumption taxes, and very large transfers. The Pareto set, in comparison, remains large; the specifics of these calculations are available upon request.

The large transfers arise because, as shown by Chatterjee (1994) and Krusell and Ríos-Rull (1999), there is no mobility in this model. The low labor income taxes arise for the same reasons here – most majorities depend on labor income, so they oppose taxing it, and prefer to tax the source of factor income they do not have (capital).

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OECD Average Tax Rates, 1990–2000
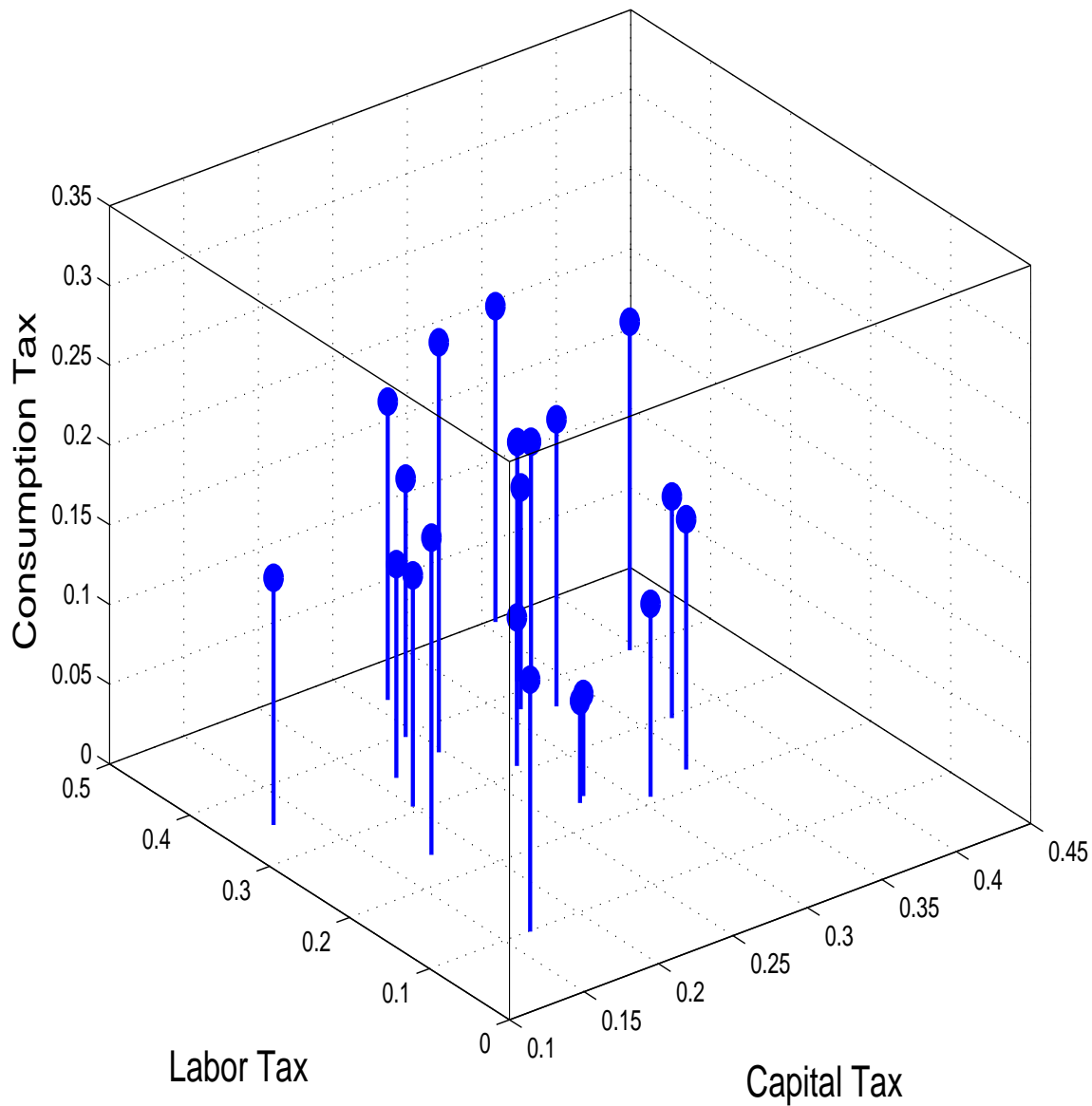
Figure 2: Lorenz curves for earnings
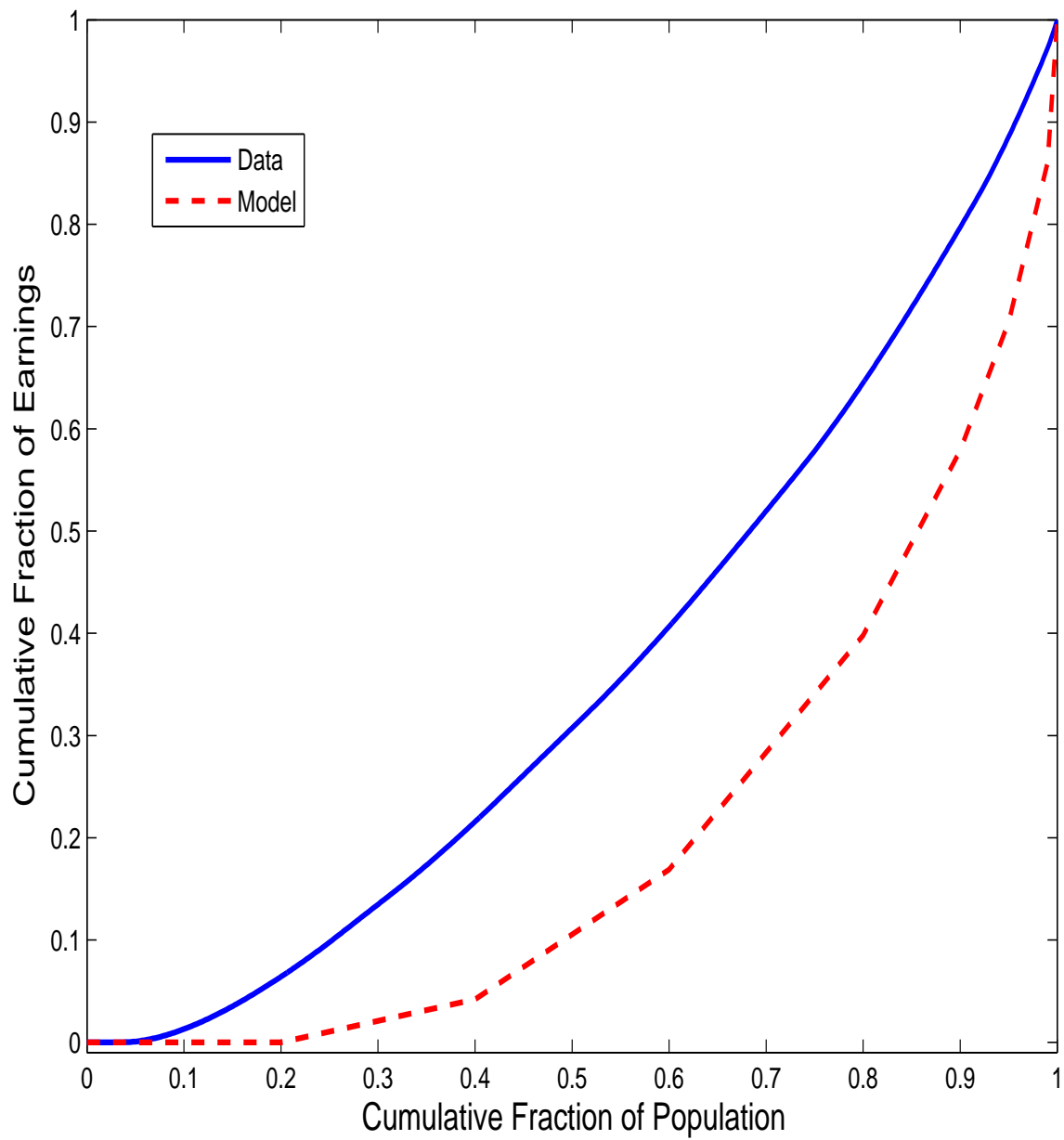
Figure 3: Lorenz curves for wealth
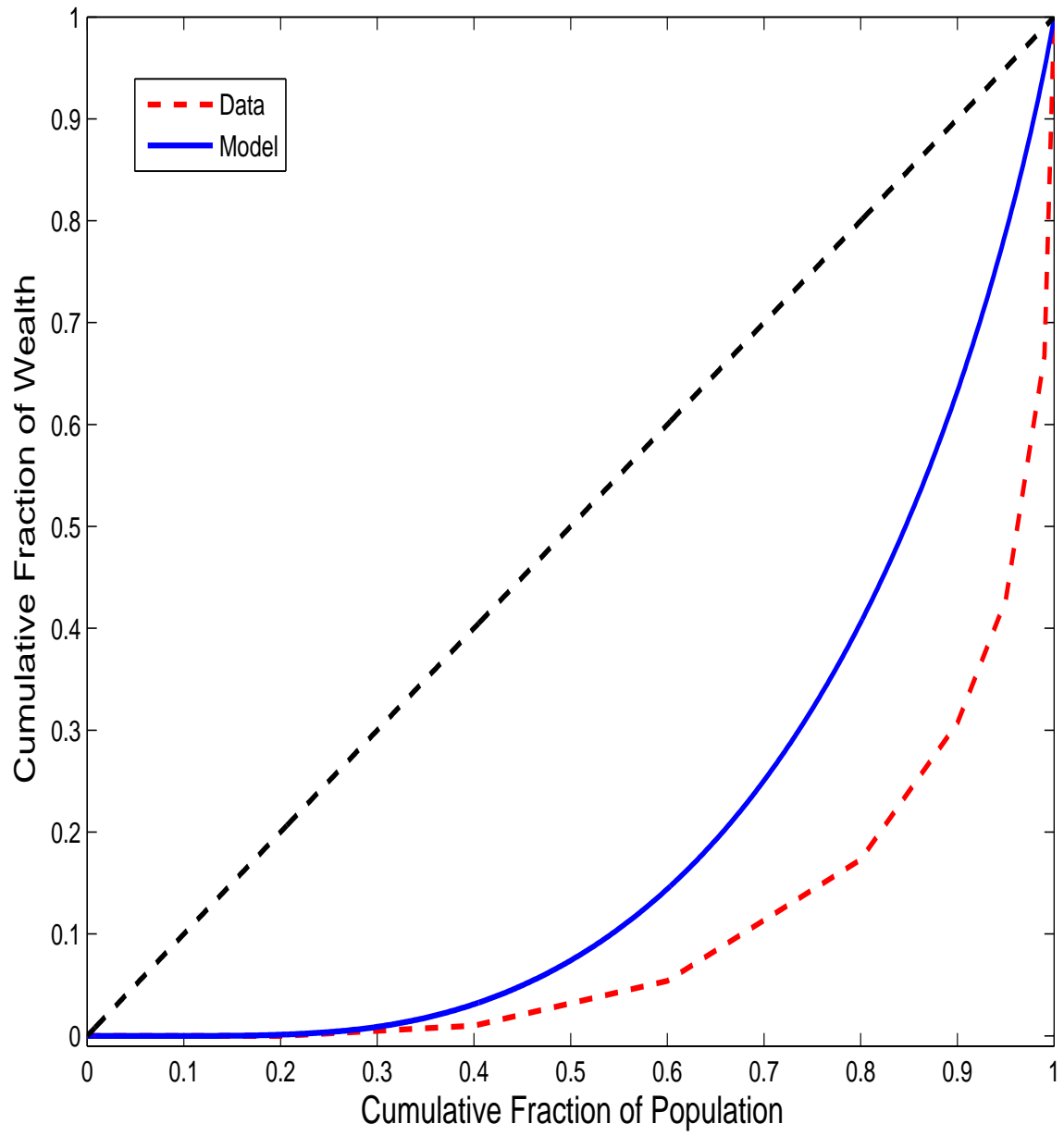
Figure 4: Preferences over consumption taxes

τ_c: 0.3, τ_l: 0, τ_k: 0.2
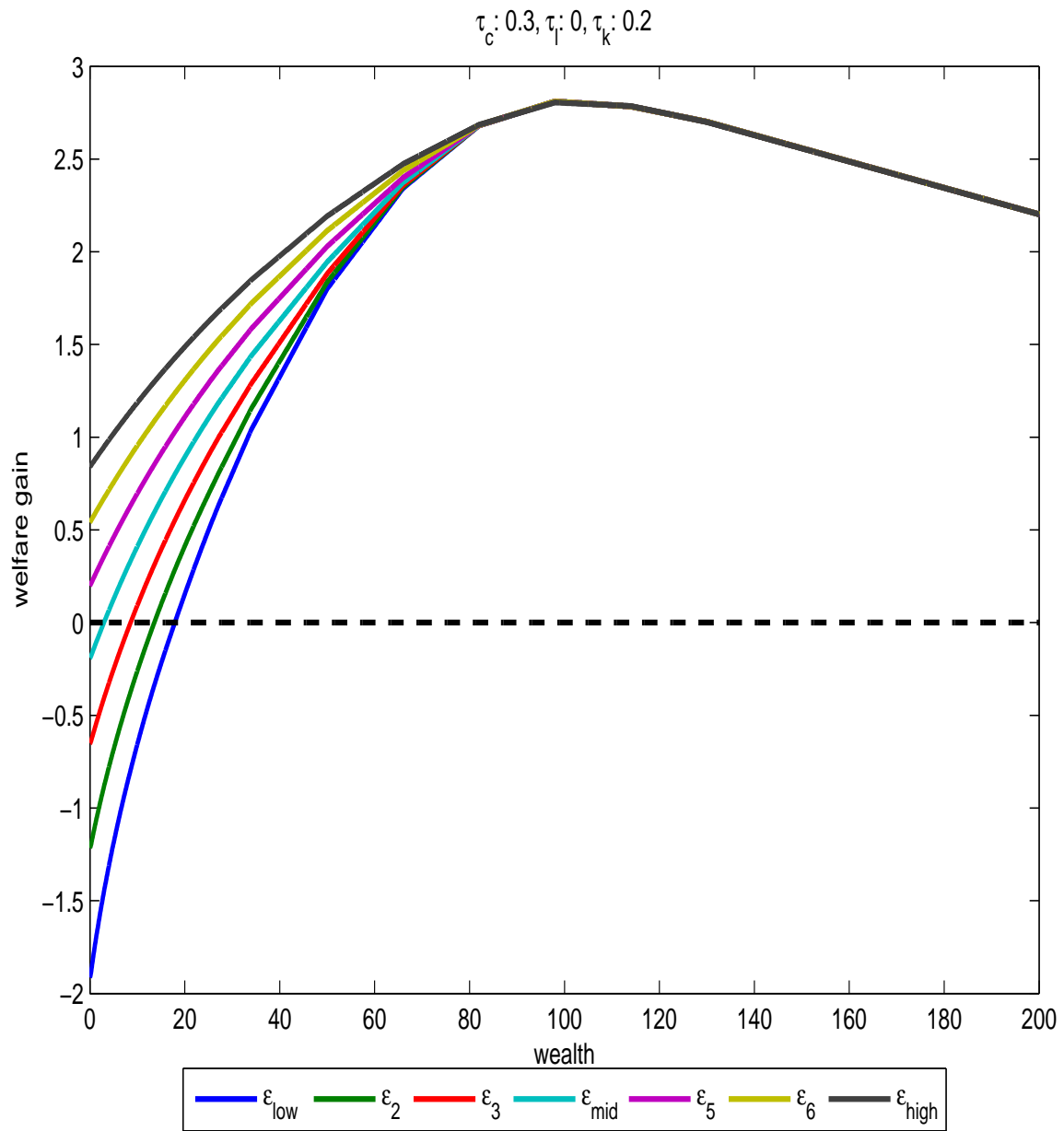
Figure 5: Preferences over consumption taxes

τ_c: 0.6, τ_l: 0, τ_k: 0.2
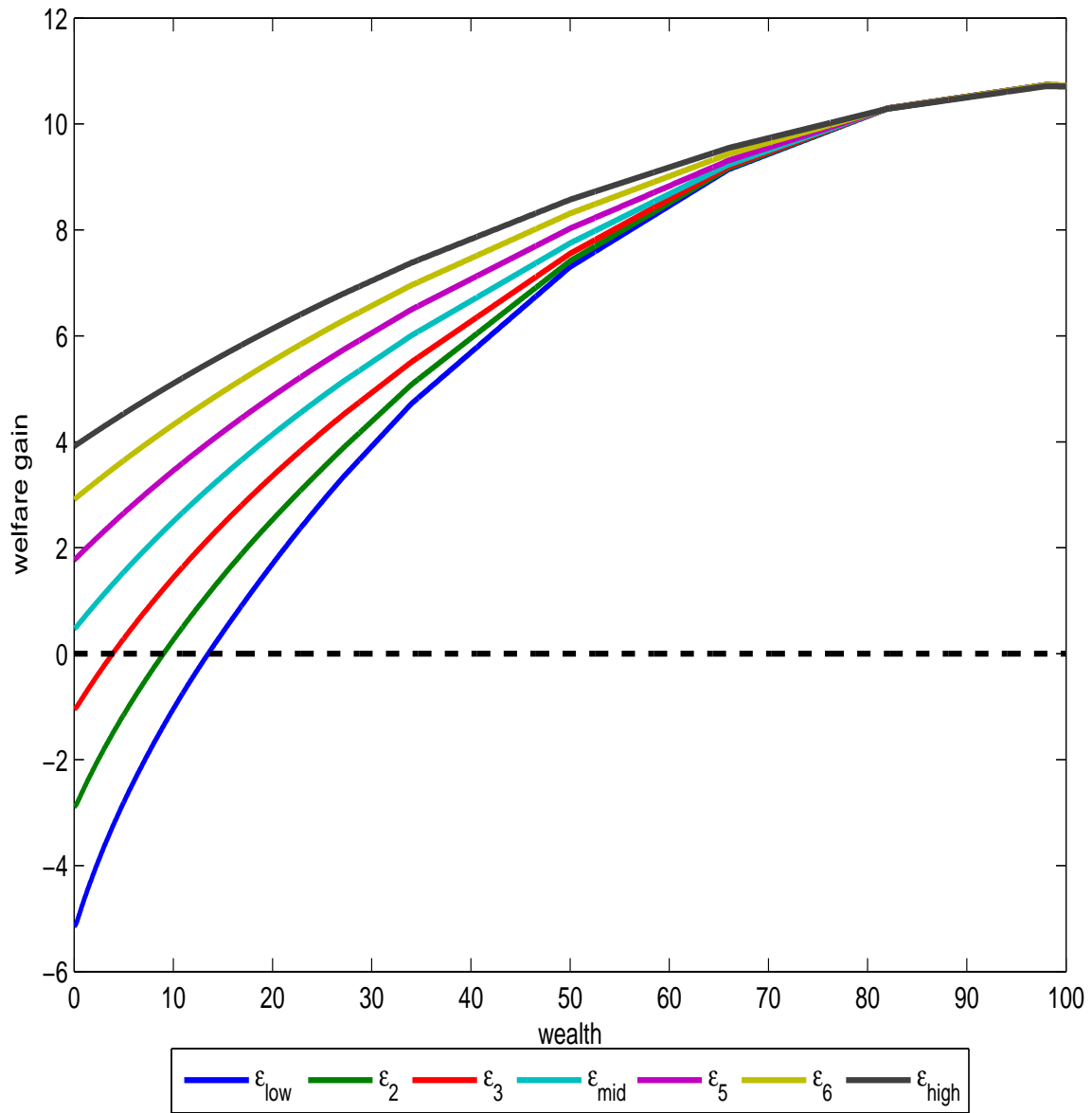
Figure 6: Preferences over consumption taxes

τ_c: 1.5, τ_l: 0, τ_k: 0.2
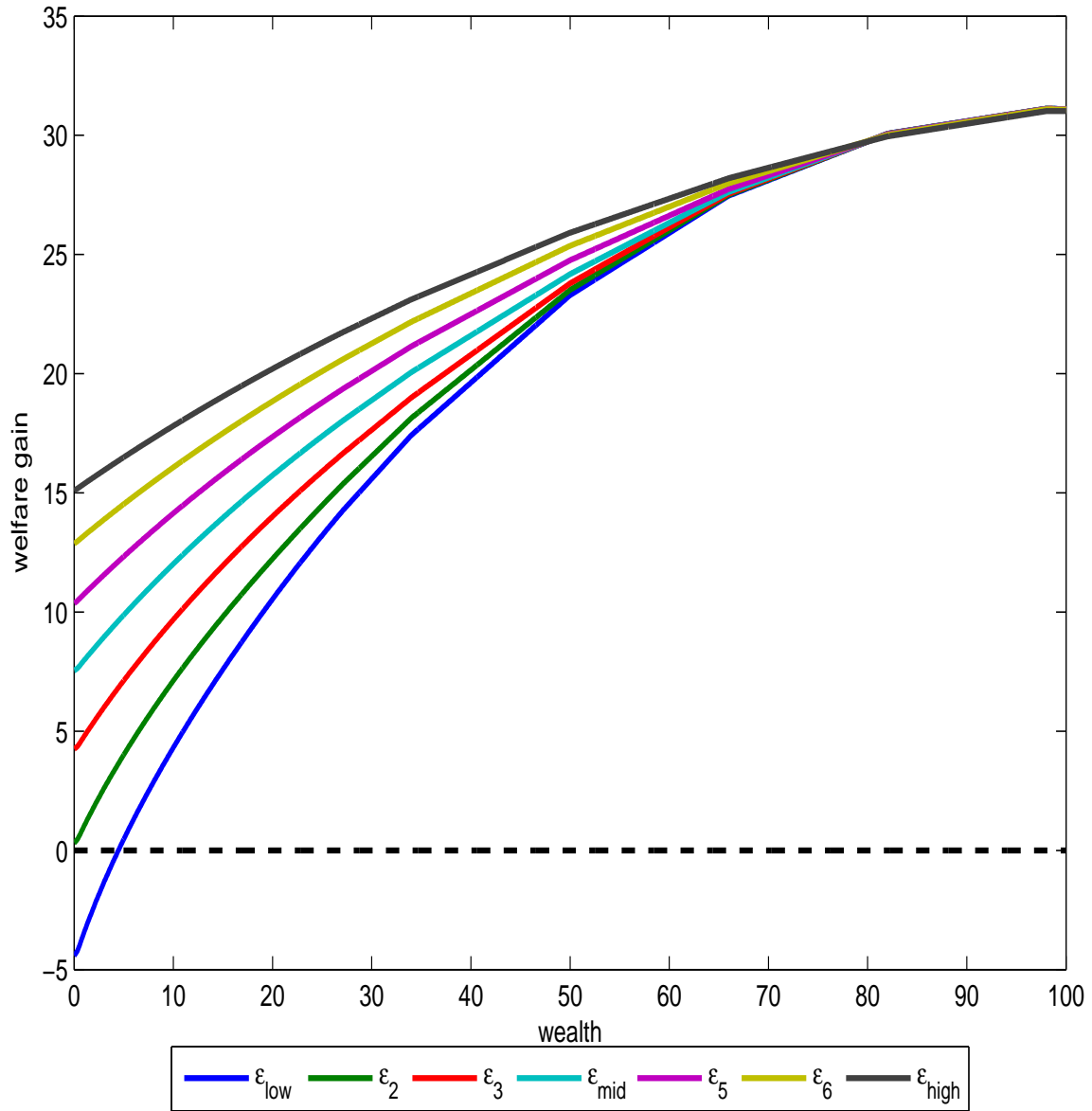
Figure 7: Hours supply decision under coarse grid Condorcet winner
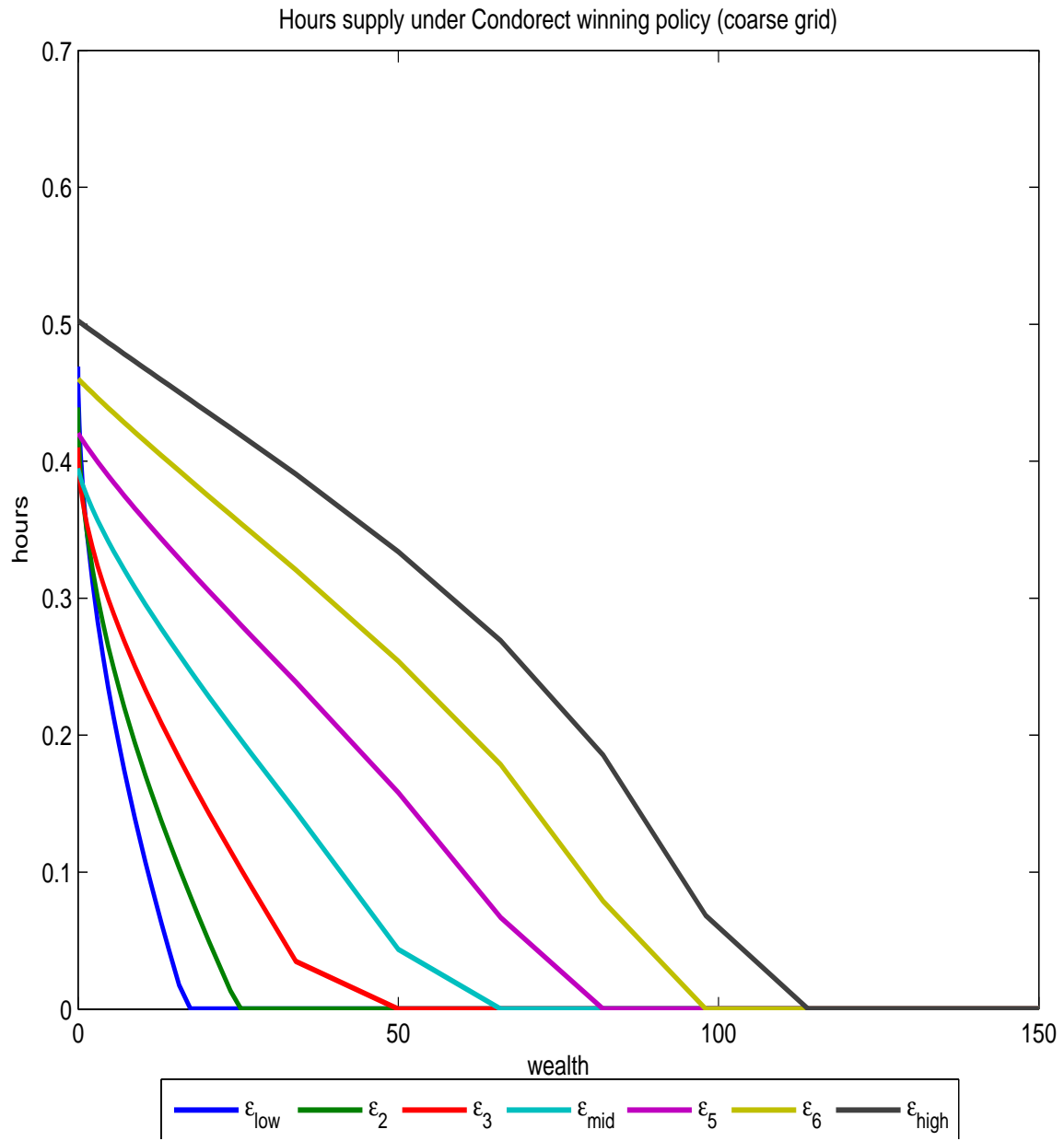
Figure 8: Share of votes for alternative with a higher consumption tax

Share of population voting against Condorcet winner
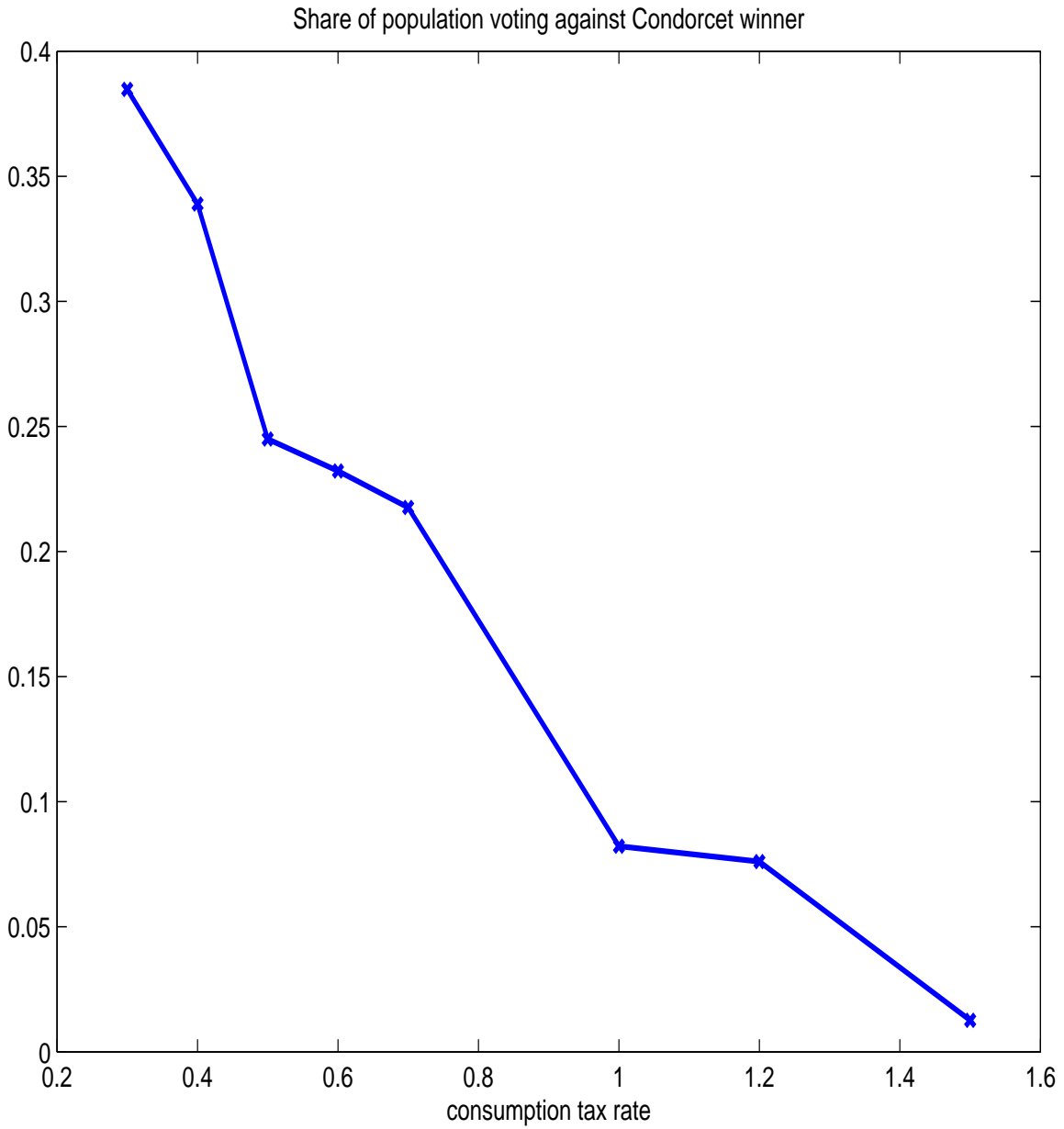
Figure 9: Preferences over capital income taxes

τ_c: 0.2, τ_l: 0, τ_k: 0.3
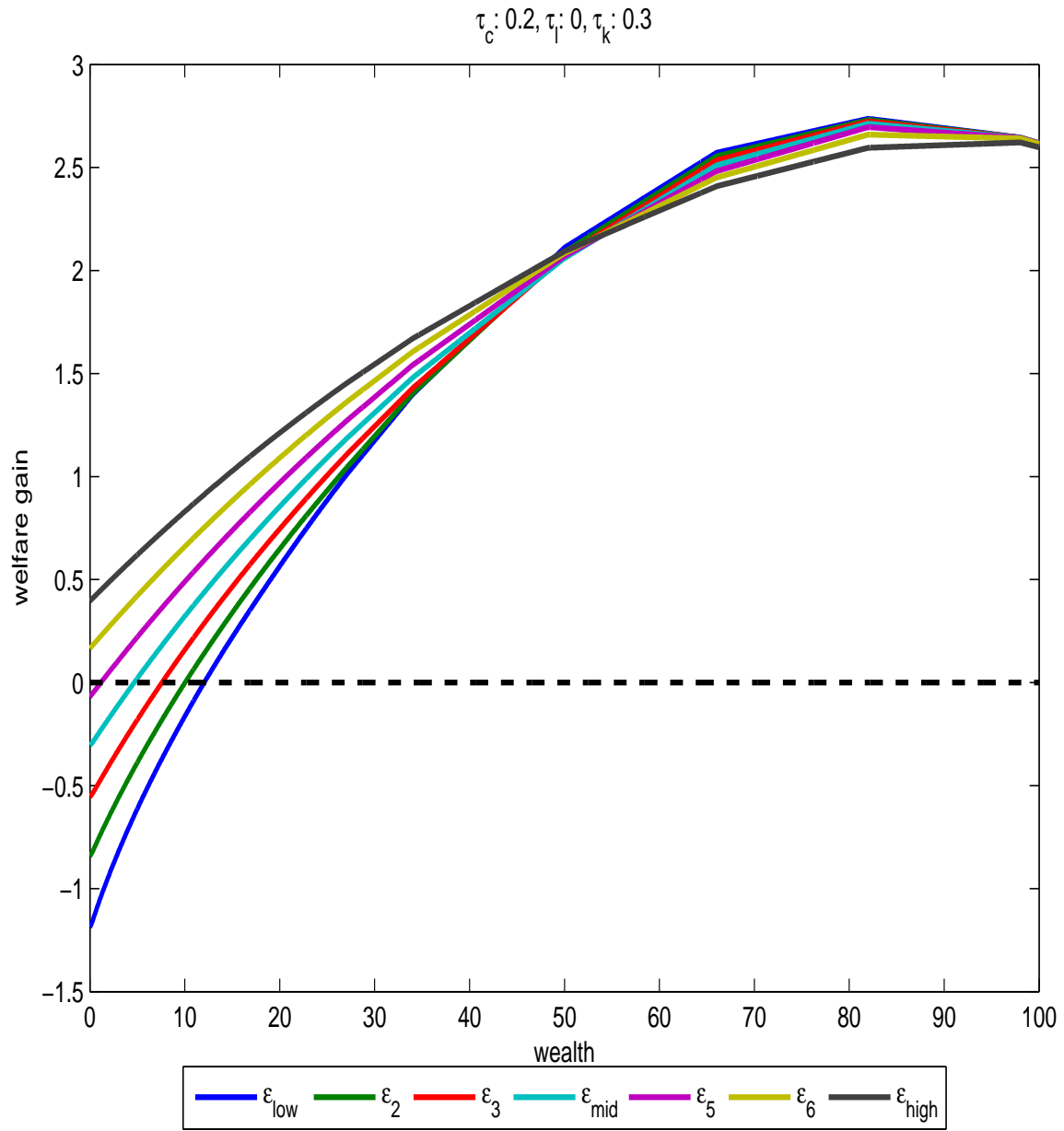
Figure 10: Preferences over capital income taxes

τ_c: 0.2, τ_l: 0, τ_k: 0.5
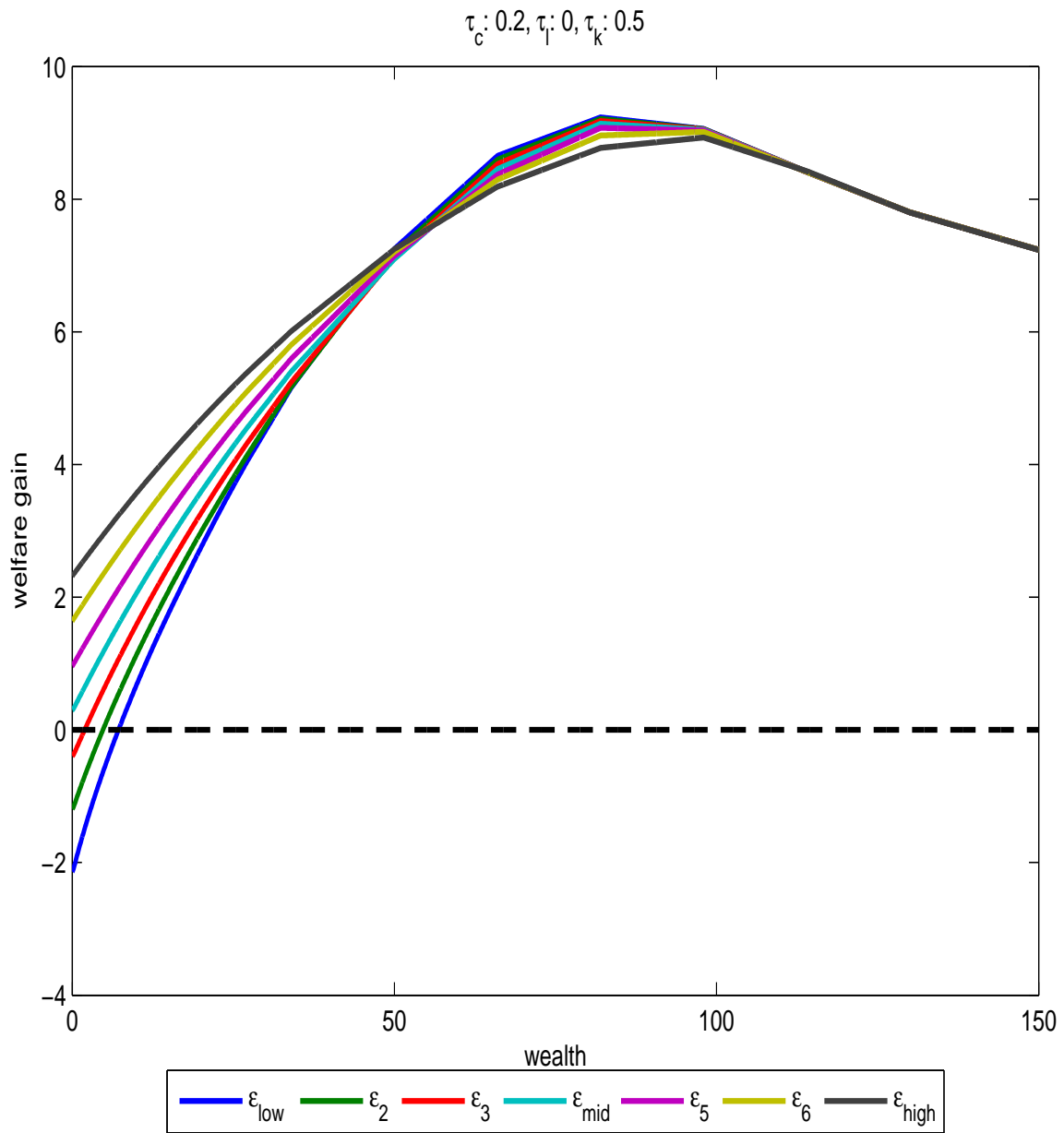
Figure 11: Preferences over capital income taxes

τ_c: 0.2, τ_l: 0, τ_k: 0.7
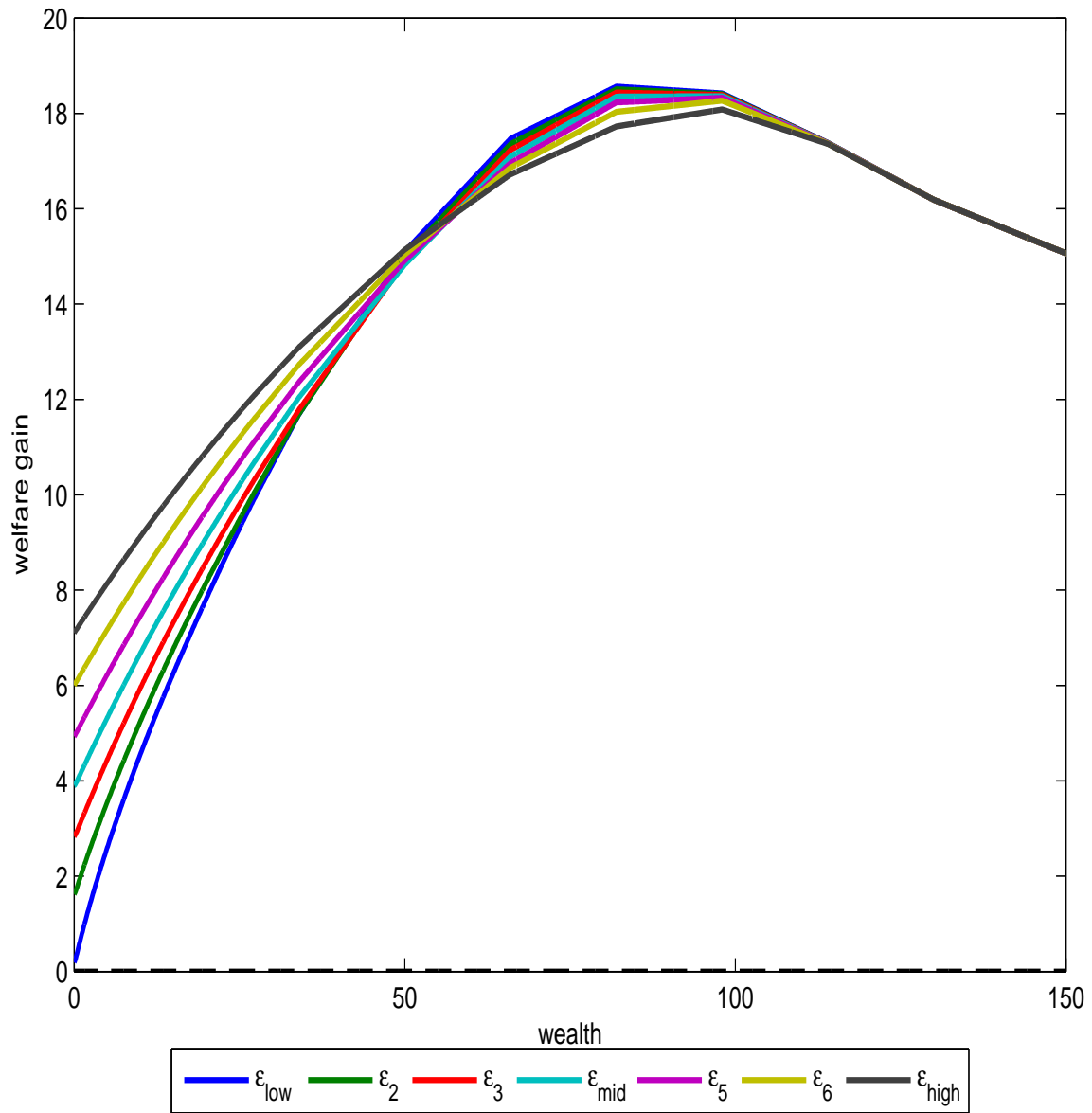
Figure 12: Share of votes for alternative with a higher capital income tax

Share of population voting against Condorcet winner

Capital income tax rate
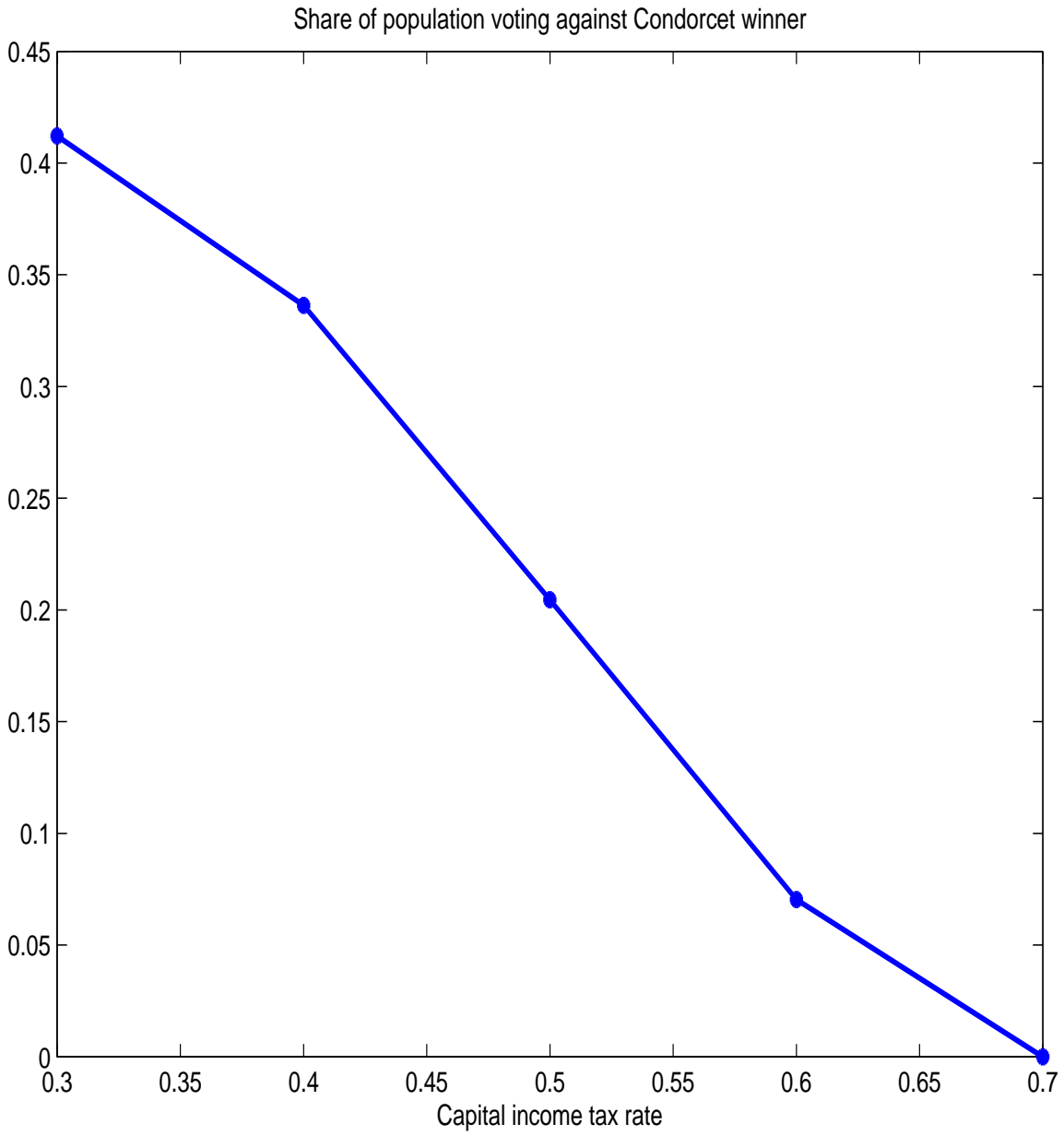
Figure 13: Preferences over labor income taxes

τ_c: 0.2, τ_l: 0.1, τ_k: 0.2
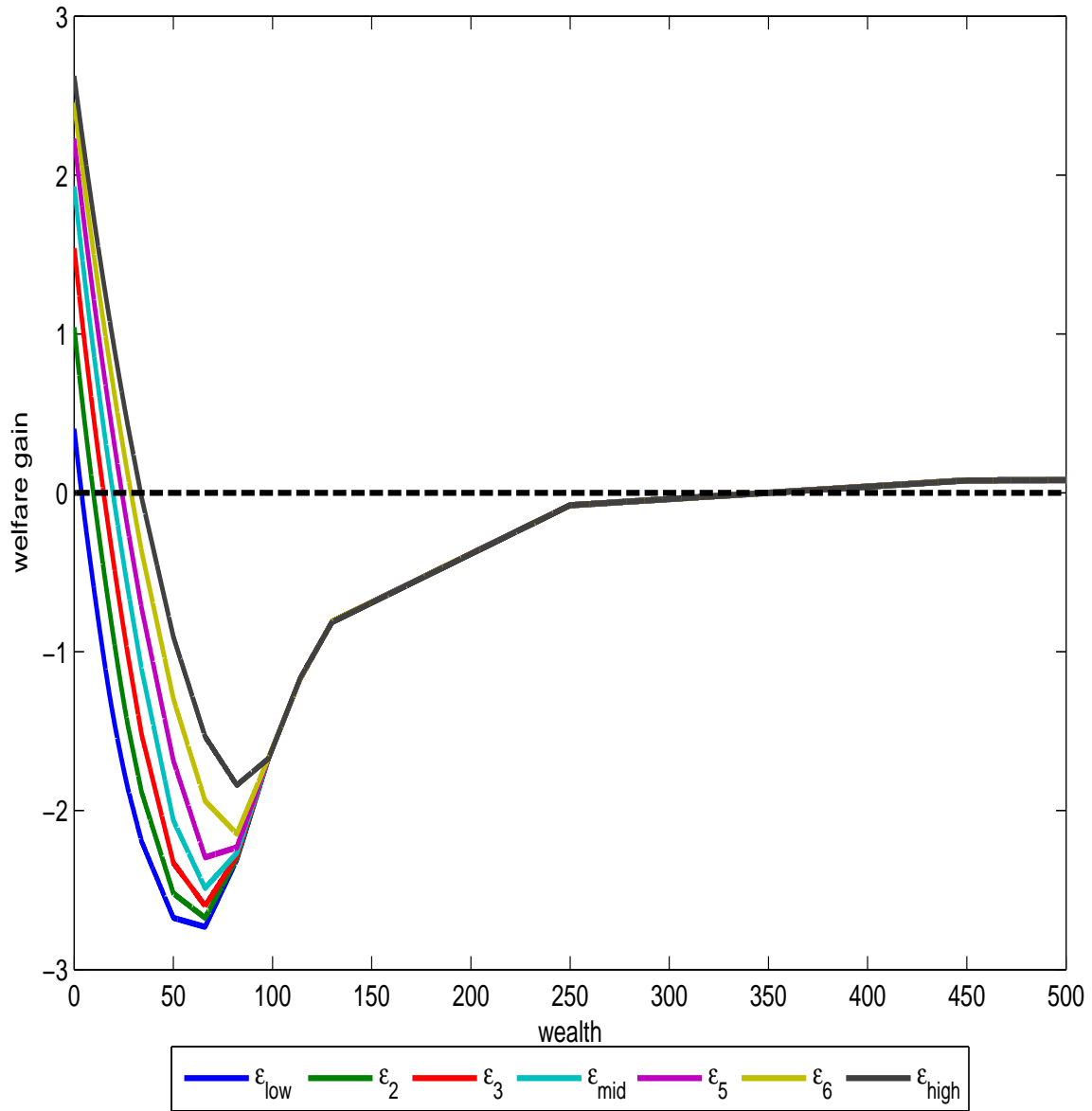
Figure 14: Preferences over labor income taxes

τ_c: 0.2, τ_l: 0.3, τ_k: 0.2
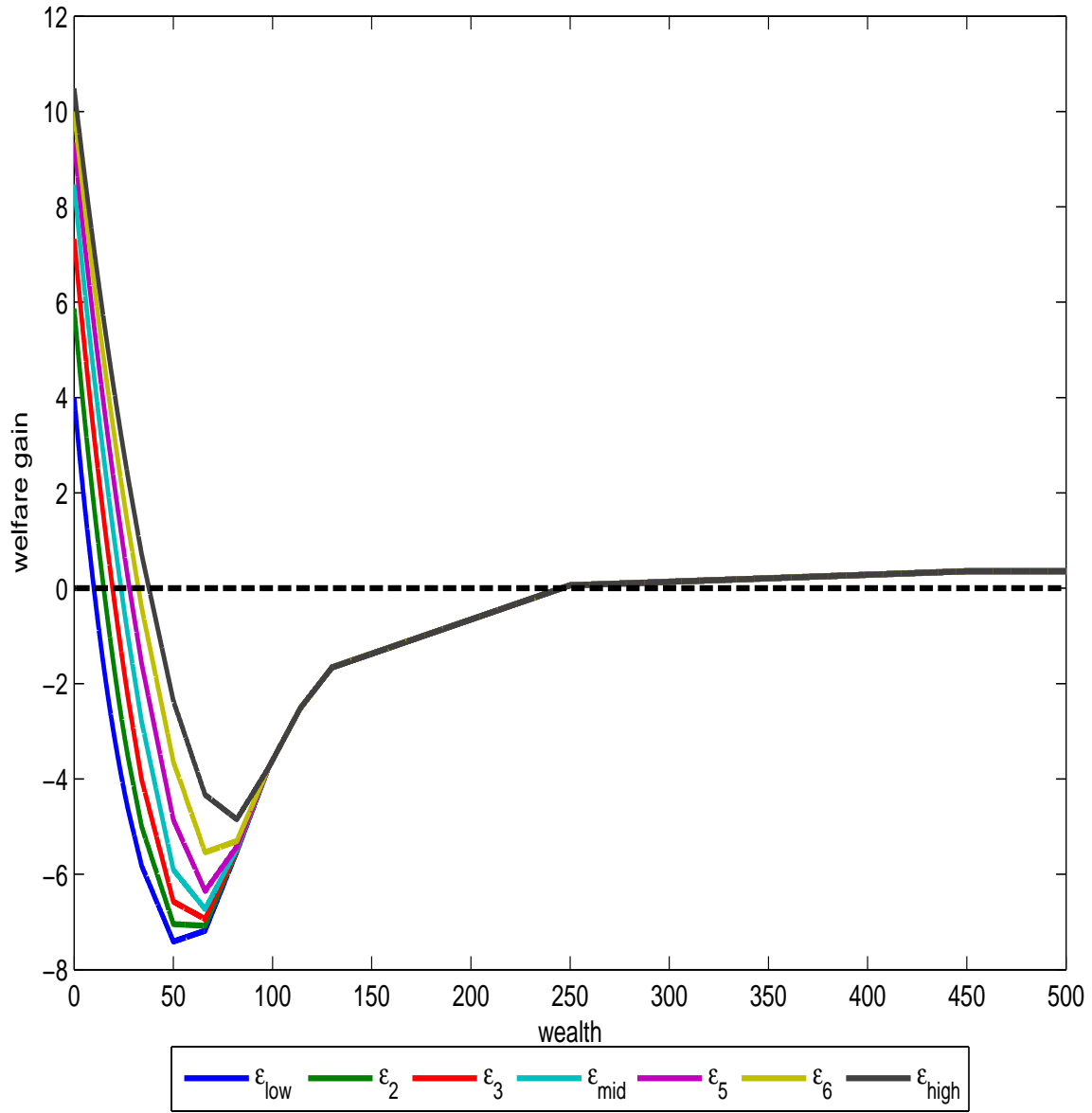
Figure 15: Preferences over labor income taxes

τ_c: 0.2, τ_l: 0.6, τ_k: 0.2
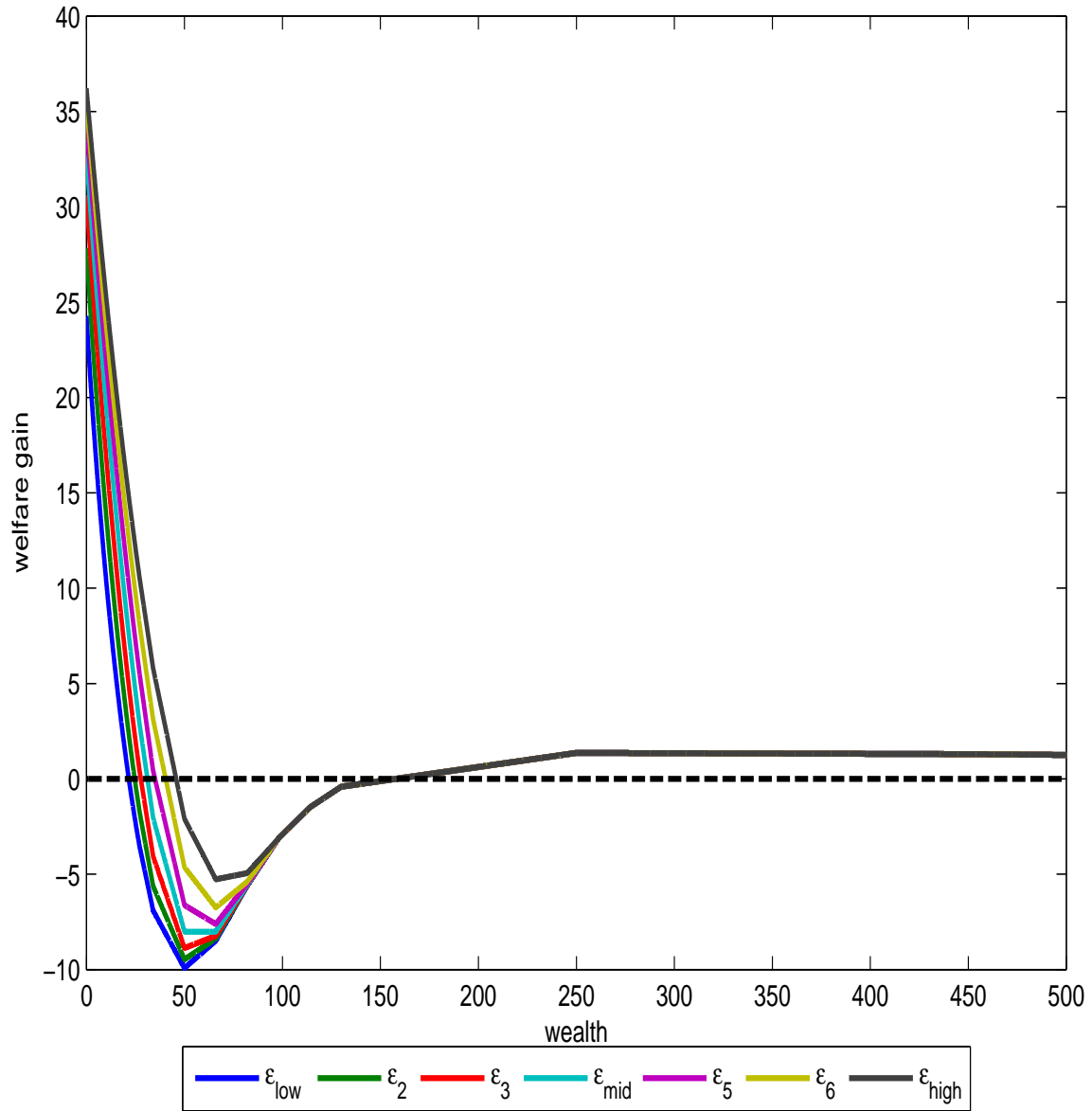
Figure 16: Share of votes for alternative with a higher labor income tax

Share of population voting against Condorcet winner

Labor income tax rate
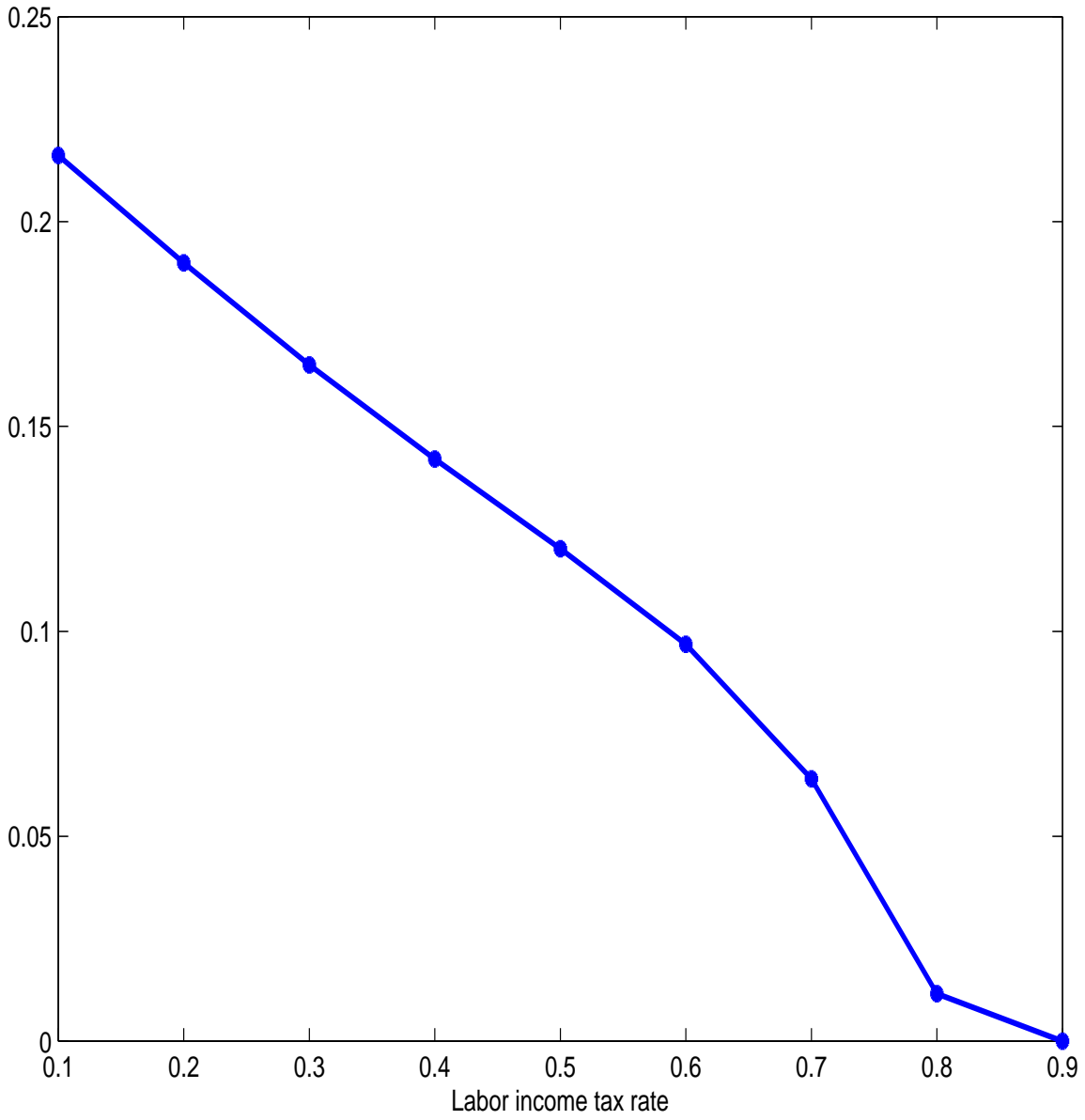
Figure 17: Most preferred tax combination of lowest productivity households

Preferred tax policy (low ε)
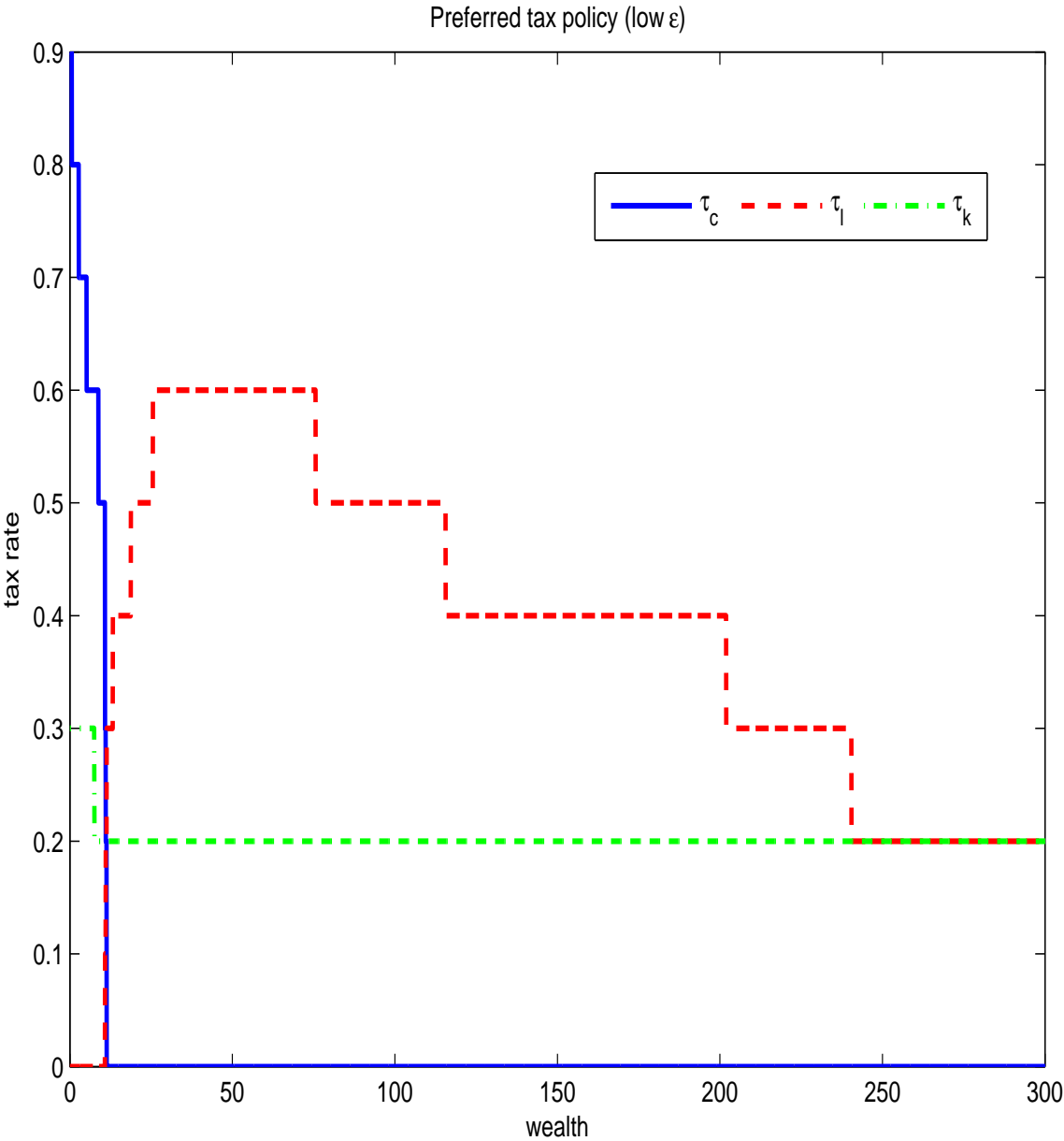
Figure 18: Most preferred tax combination of median productivity households

Preferred tax policy (median ε)
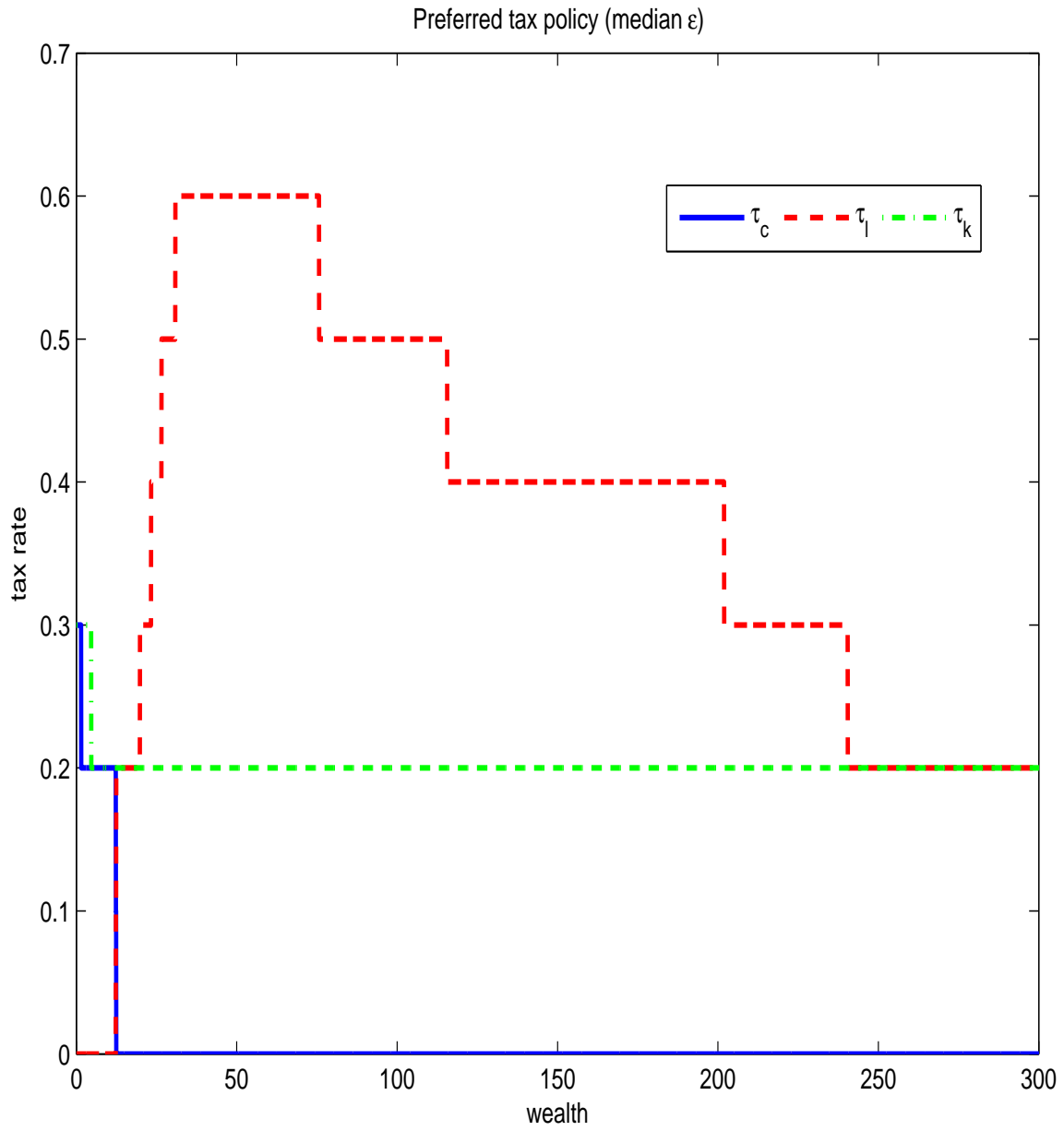
Figure 19: Most preferred tax combination of highest productivity households

Preferred tax policy (high ε)
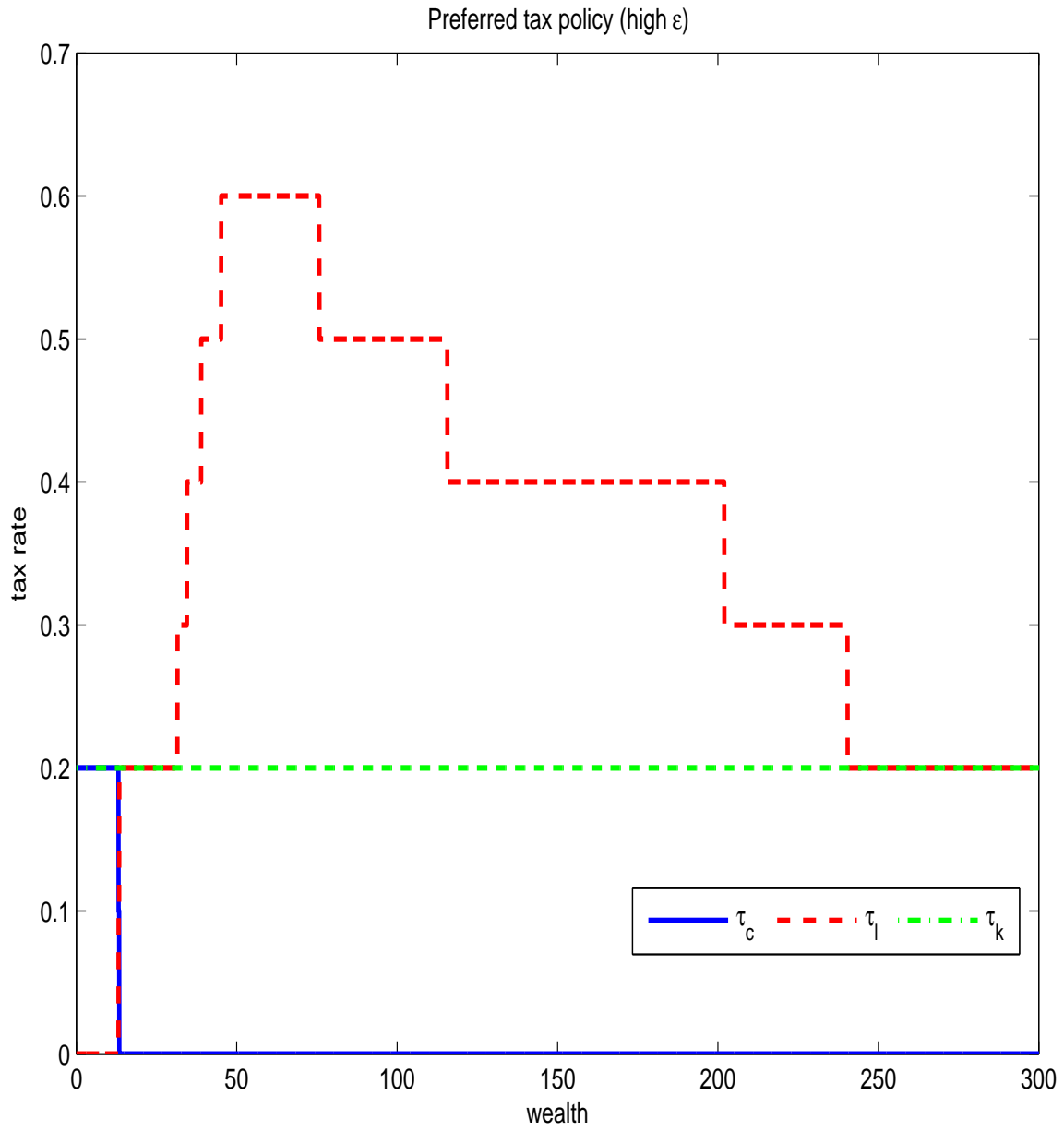
Figure 20: Most preferred tax combination of median productivity households
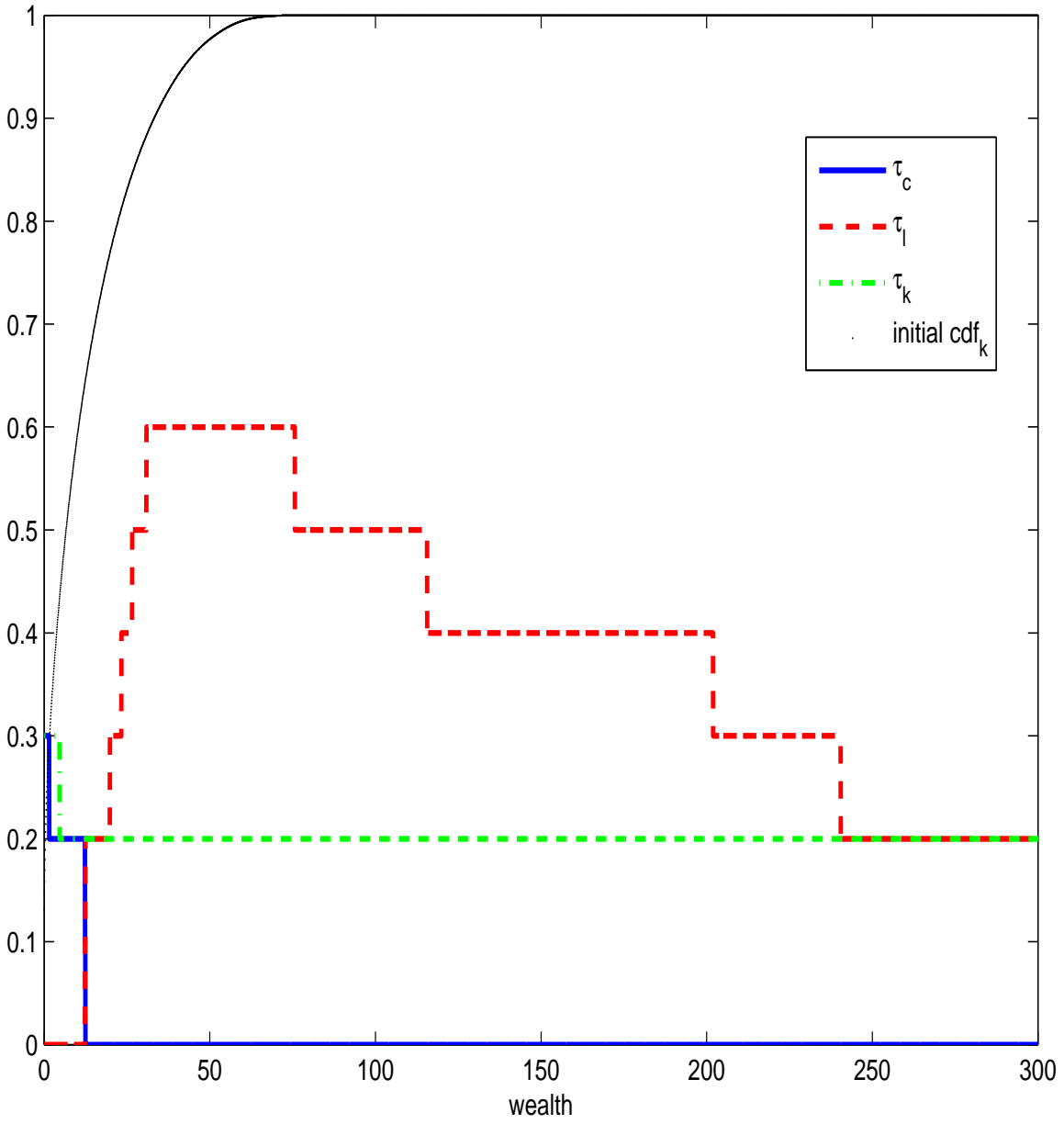
Figure 21: Transition path under Condorcet winner policy (fine grid)
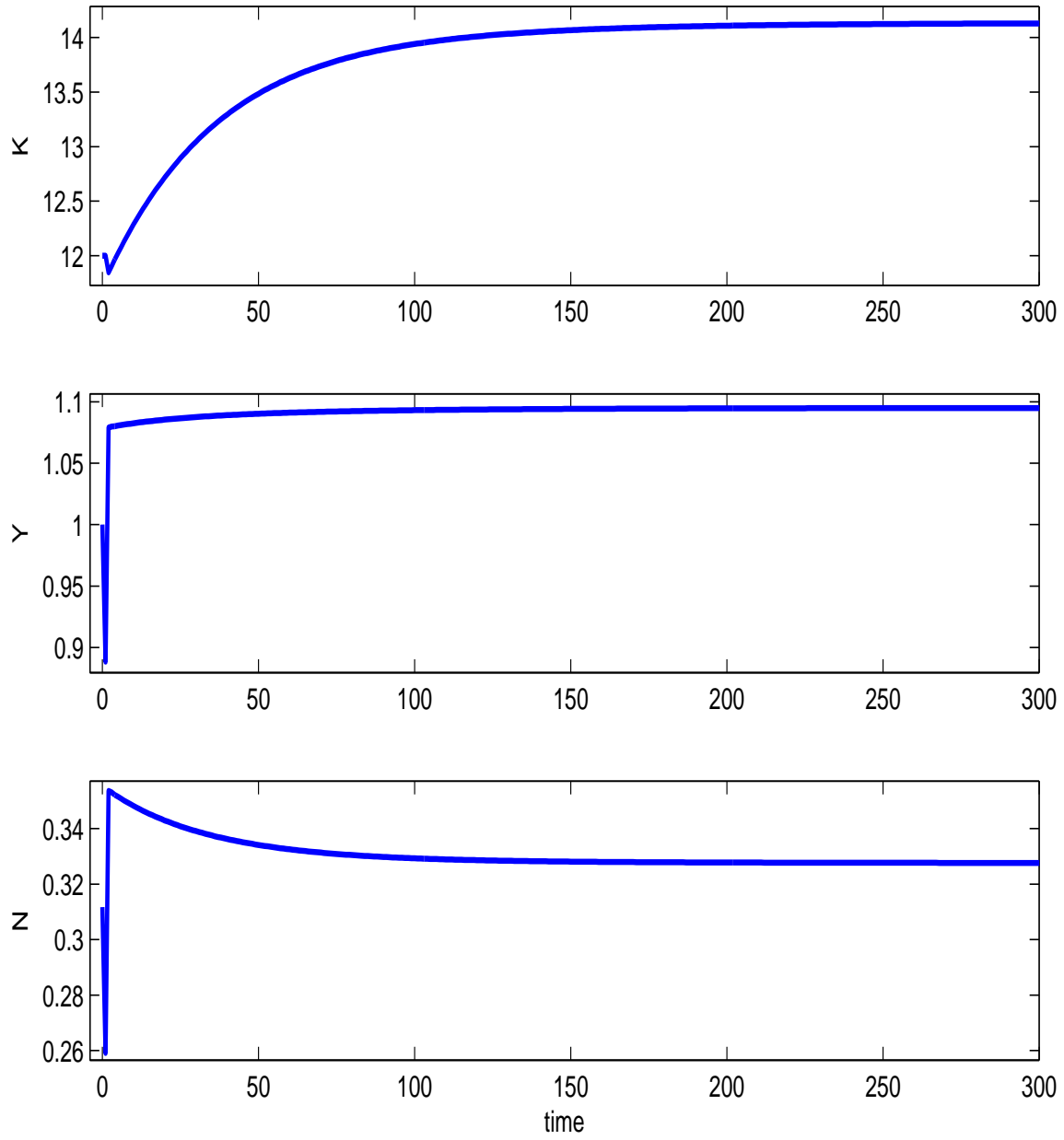
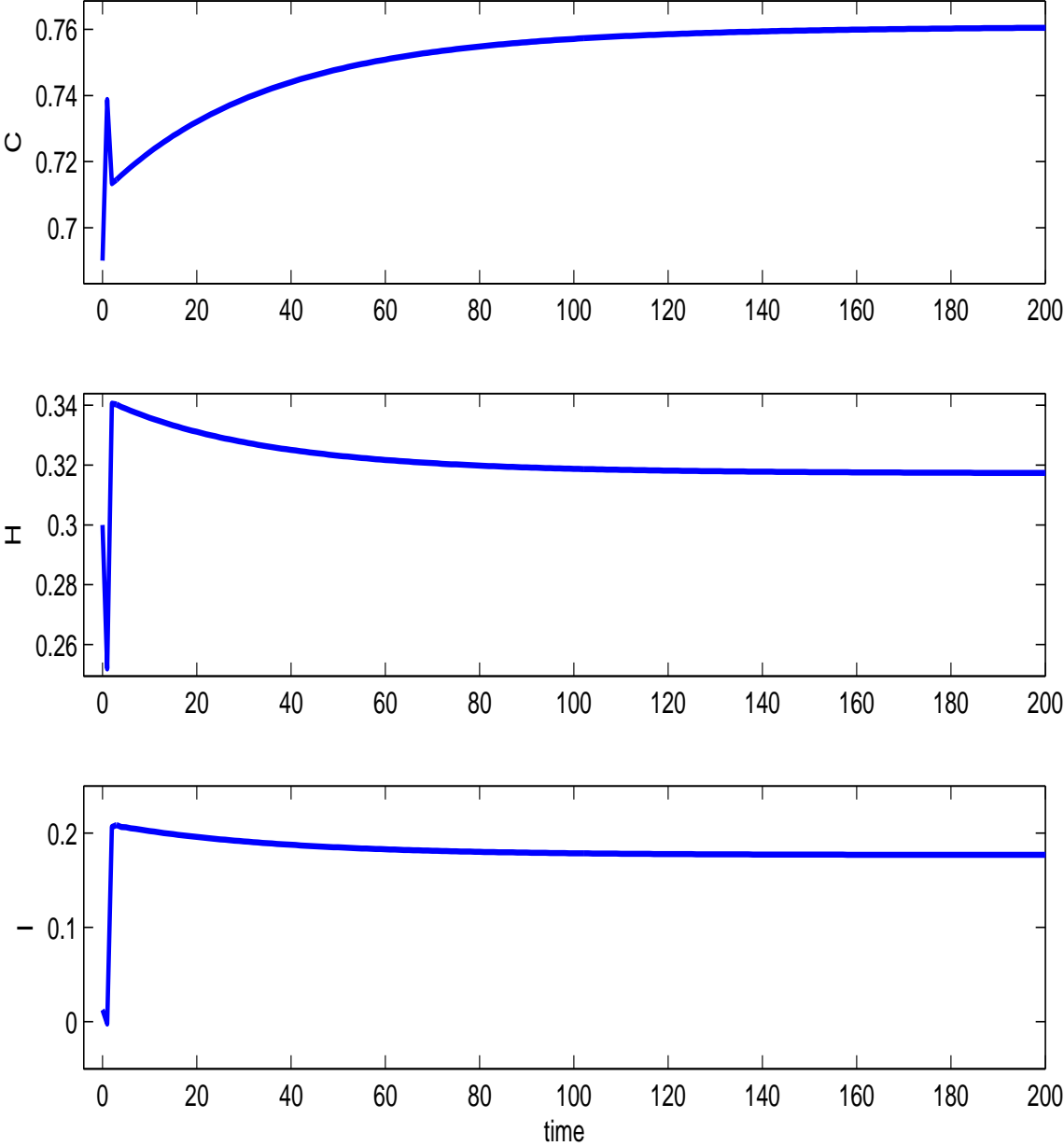Figure 22: Transition path under Condorcet winner policy (fine grid)

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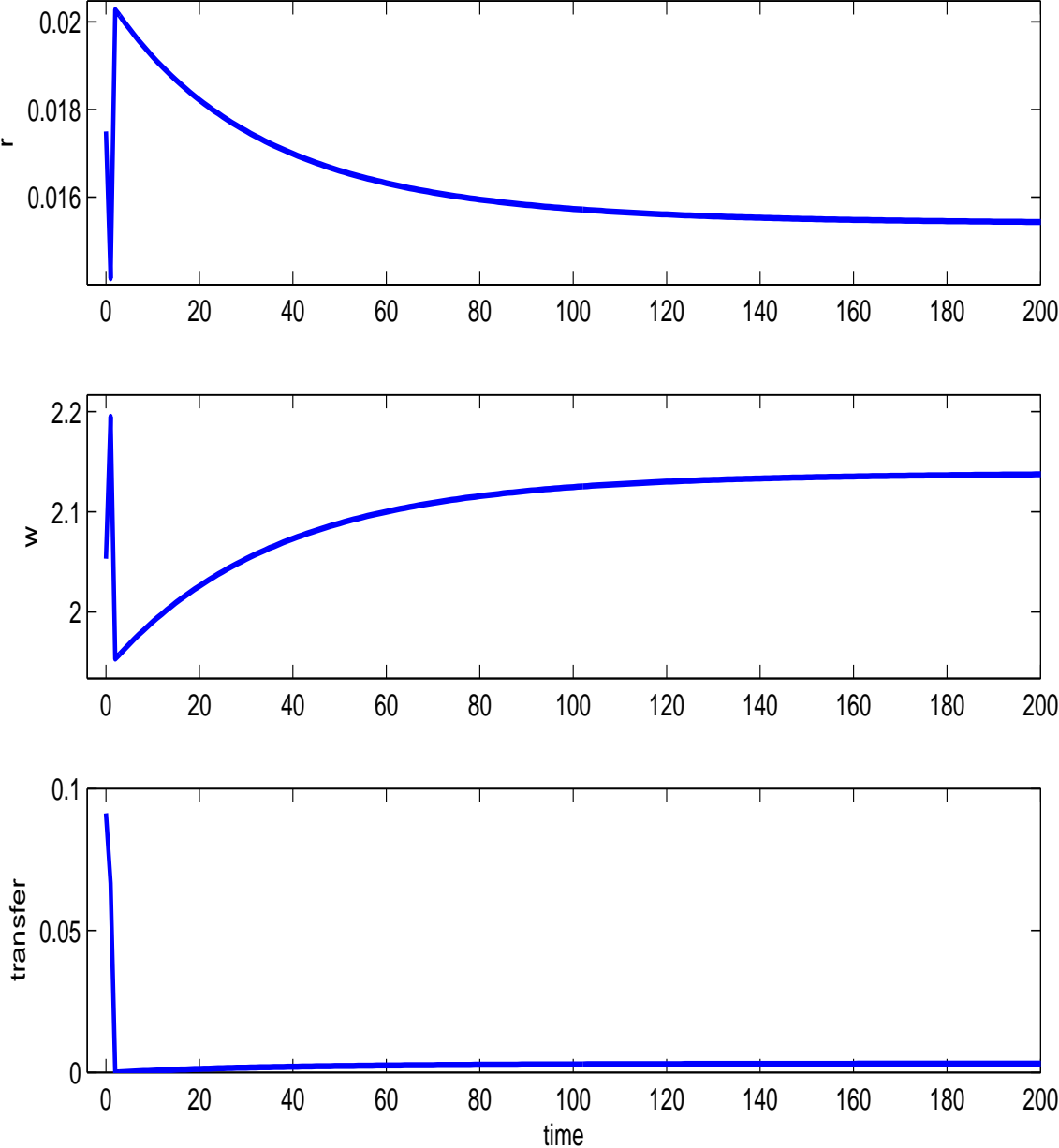Figure 23: Transition path under Condorcet winner policy (fine grid)

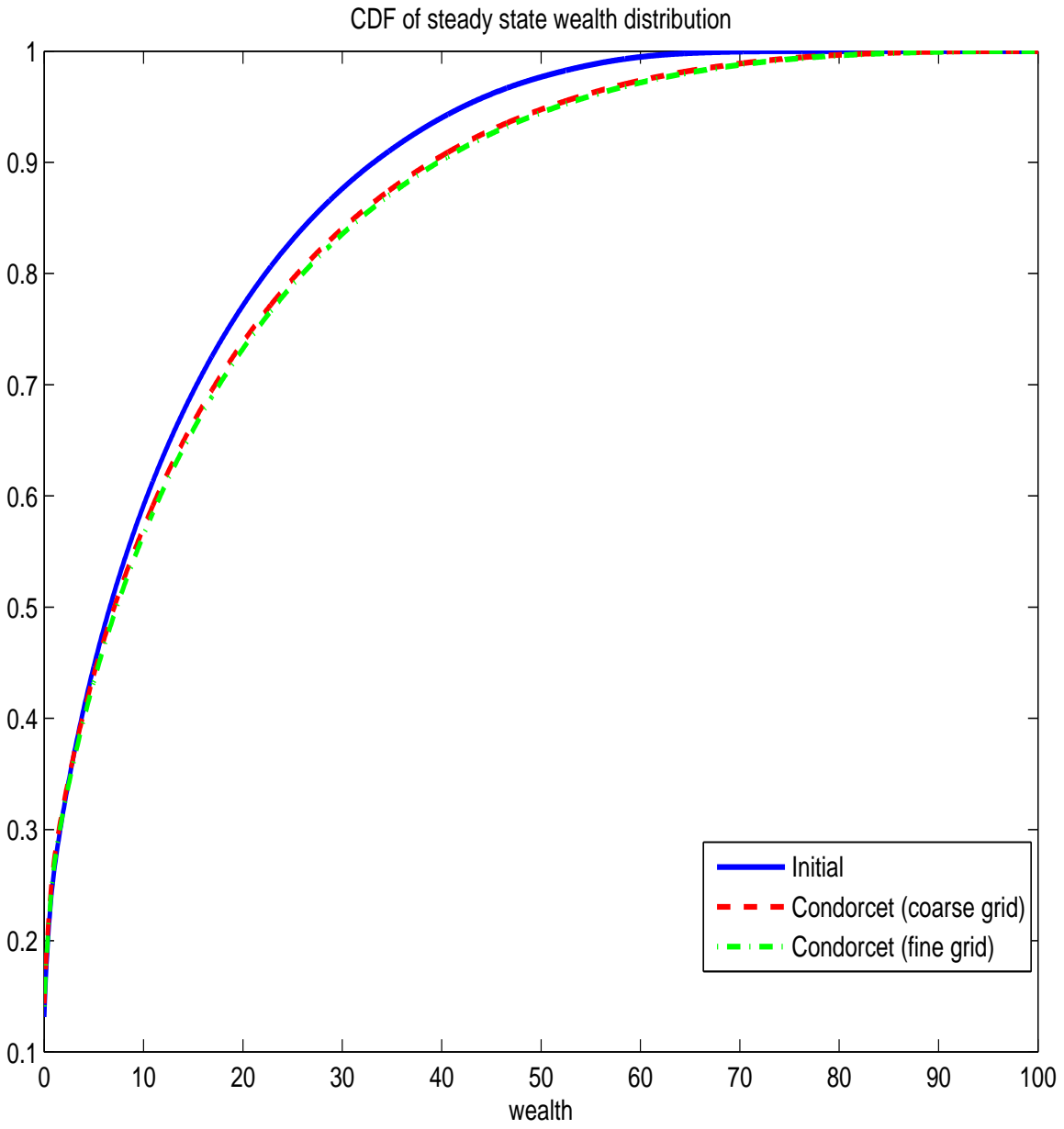Figure 24: Cumulative distribution functions of wealth

Figure 25: Cumulative distribution functions of wealth

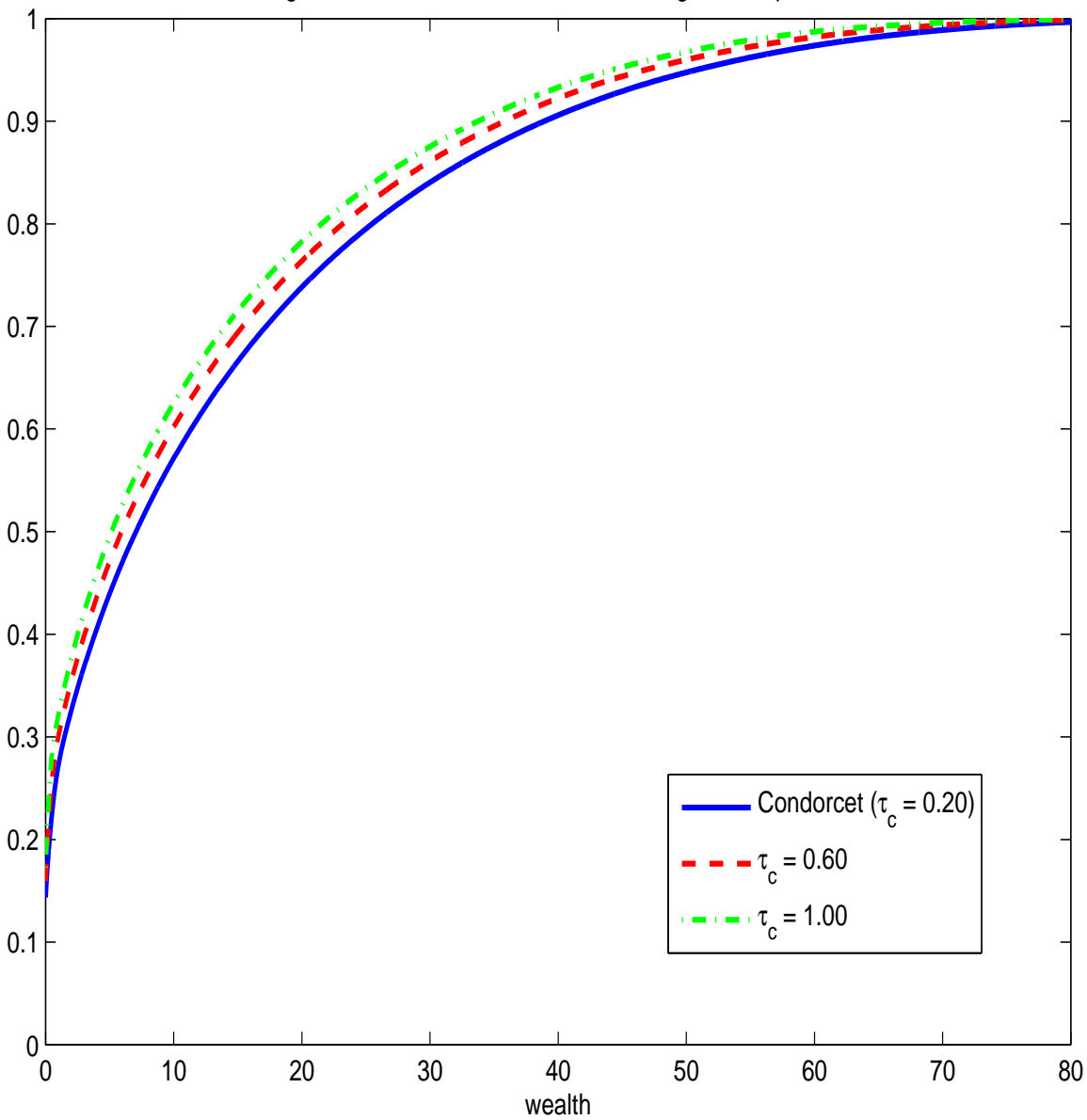Change in wealth distribution from increasing consumption taxes

Figure 26: Cumulative distribution functions of wealth

Changes in steady state wealth distribution from increase in capital income tax
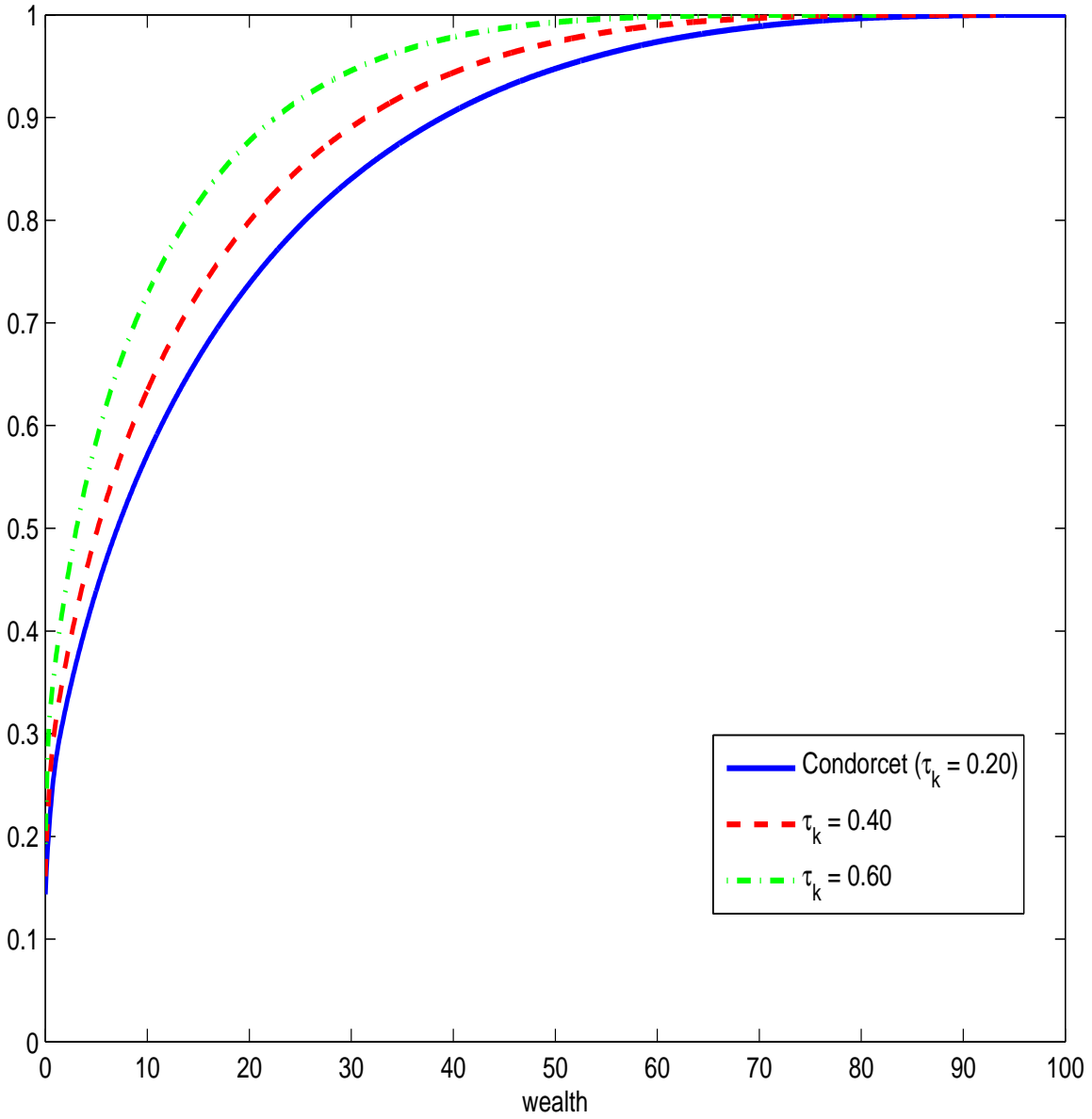
Legend:
- Condorcet ($\tau_k = 0.20$) — blue solid line
- $\tau_k = 0.40$ — red dashed line
- $\tau_k = 0.60$ — green dash-dot line

x-axis: wealth

Figure 27: Cumulative distribution functions of wealth
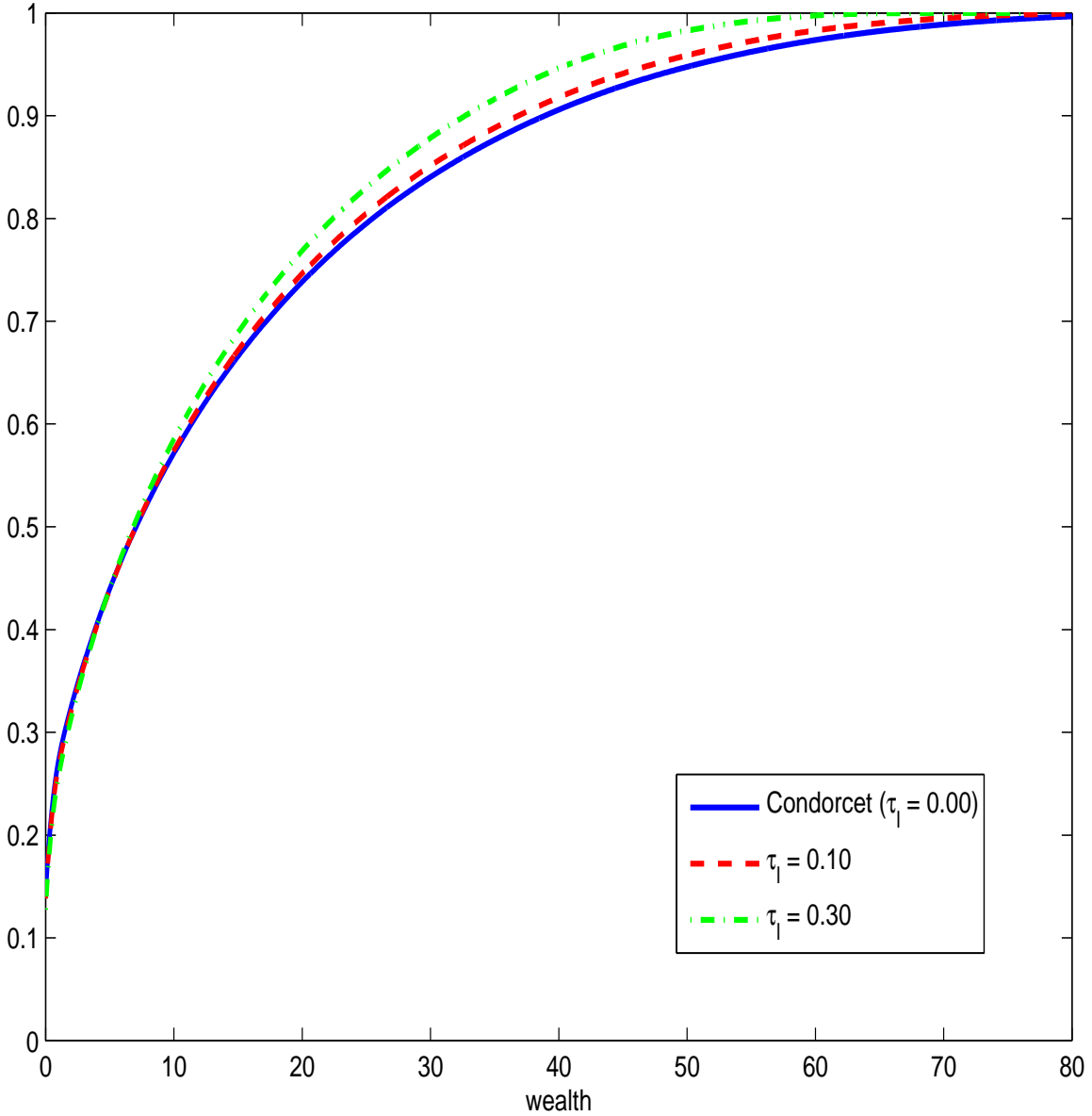
Figure 28: Uncovered set in Dolmas model
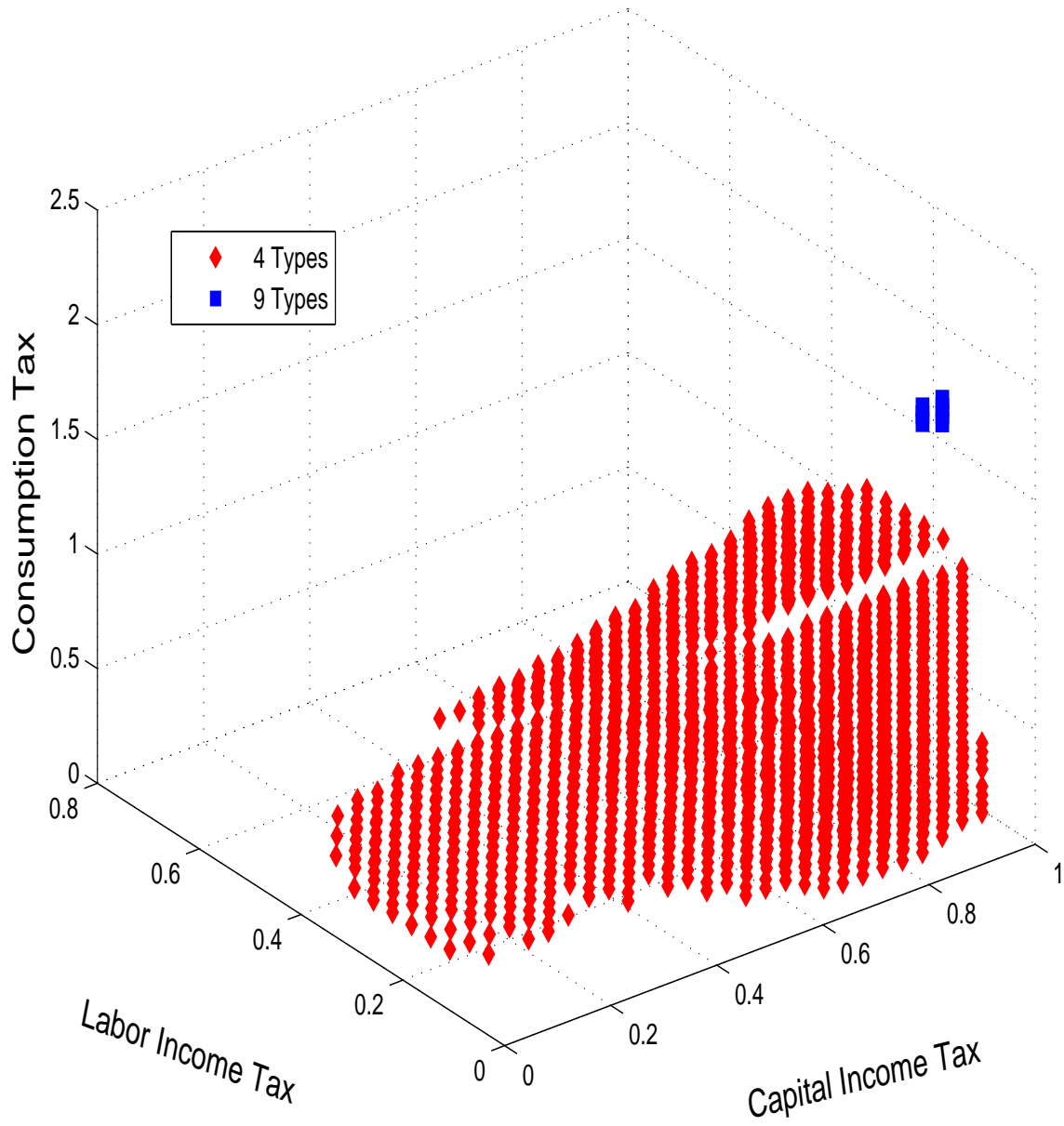
Table 1: Calibrated Parameters

Parameter	Value
β	0.986
Z	0.862
θ	2.203
T	0.091

Table 2: Earnings Mobility

Data	1	2	3	4	5
1	**0.90**	0.07	0.02	0.01	0.00
2	0.27	0.34	0.30	0.06	0.02
3	0.09	0.14	0.45	0.25	0.06
4	0.05	0.06	0.15	0.51	0.23
5	0.05	0.05	0.06	0.17	**0.68**
Model	1	2	3	4	5
1	**0.58**	0.20	0.13	0.06	0.03
2	0.16	0.35	0.21	0.20	0.07
3	0.11	0.15	0.39	0.16	0.18
4	0.08	0.19	0.09	0.41	0.22
5	0.07	0.09	0.18	0.17	**0.49**

Table 3: Wealth Mobility

Data	1	2	3	4	5
1	0.63	0.26	0.07	0.03	0.02
2	0.27	0.45	0.17	0.07	0.03
3	0.07	0.22	0.45	0.20	0.06
4	0.03	0.05	0.26	**0.45**	0.21
5	0.01	0.03	0.05	0.25	**0.67**
Model	1	2	3	4	5
1	0.76	0.23	0.01	0.00	0.00
2	0.24	0.55	0.21	0.01	0.00
3	0.00	0.22	0.61	0.17	0.00
4	0.00	0.00	0.17	**0.72**	0.11
5	0.00	0.00	0.00	0.11	**0.89**