Government Purchases Over the Business Cycle: the Role of Heterogeneity and Wealth Bias in Political Decision Making

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Abstract

This paper sets up and computes a stochastic neoclassical growth model where agents face uninsurable idiosyncratic labor income risk and heterogenous discount factors. Households value government purchases which are financed by income taxes. The government cannot commit to future streams of government purchases. We thus study the Markov perfect equilibria of such an economy. We also introduce a wealth bias into the political aggregation process. When exposed to standard aggregate productivity shocks, we show that such a model can explain three important features of government purchases in the data: government purchases are mildly procyclical, their dynamic correlation with one-year lagged output is higher than the corresponding contemporaneous correlation, and they are the most persistent component of aggregate demand. We also show that a representative agent model, models with insufficient wealth inequality and models with no wealth bias cannot explain these features of the data.

JEL Codes: E30, E32, E60, E62, P16.

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1 Introduction

Standard business cycle analysis typically treats government purchases[1] as an exogenous stochastic process. As such they appear in three different strands of the literature: in standard business cycle models as a wedge and potential driving force (see Baxter and King, 1992, and Chari et al., 2007, for instance); in the vast empirical literature on the sign and size of the government spending multiplier as an exogenous shock source to be identified (see Ramey, 2009, for example); and in the optimal fiscal policy literature (see Chari and Kehoe, 1999, and Kocherlakota, 2010, for an overview), where there is an exogenous stream of government purchases to be financed by either taxes or debt.

In this paper, we tackle a different question: can the observed government purchases dynamics be explained endogenously in a neoclassical growth model with aggregate productivity shocks and a political decision mechanism? Our starting point are the following four observations about the dynamics of annual government purchases: First, government purchases are at least as volatile as aggregate output. Second, government purchases are the most persistent component of domestic aggregate demand. Third, government purchases are only mildly procyclical,[2] much less so than any other domestic component of GDP. Fourth, different from aggregate output and all its other domestic components, the dynamic correlations of government purchases with one-year lagged output are higher than the contemporaneous correlations.

A small but growing literature has heretofore addressed the problem of endogenous government purchases in a dynamic environment: a quantitative macro literature that starts from an otherwise standard neoclassical growth model and uses a political aggregation mechanism, for instance majority voting, and a Markov-perfect equilibrium concept to endogenize government consumption (see Krusell and Rios-Rull, 1999, and Klein et al., 2008). This literature has so far focussed on long-run steady state analysis in the absence of aggregate uncertainty. Recently, Battaglini and Coate (2008b), building on their earlier work in Battaglini and Coate (2007, 2008a), have developed a general framework to characterize fiscal policies under legislative bargaining and with aggregate uncertainty. This literature abstracts from the neoclassical growth model set up in its economic part, for instance they use a utility function that is linear in private consumption, they abstract from capital accumulation and wealth inequality which will be an important channel in our quantitative framework. While this literature is much richer than our paper in some dimensions in that it deals with multidimensional government policies, these simplifications limit its usefulness for quantitative analysis. In this paper, we build

[1]Throughout the paper we define government purchases as "government expenditures on consumption and investment goods" as defined in Table 3.9.5 of the NIPA accounts. We thus abstract from transfers and interest payments. Often we will also use the term government consumption synonymously to government purchases.

[2]See Ilzetzki (2007) and Ilzetzki and Vegh (2008) for examples of a recent literature about government purchases being mildly procyclical, even in developed countries, where total government spending typically is acyclical.

on the quantitative macro literature and introduce aggregate uncertainty in the form of persistent productivity shocks. This allows us to quantitatively analyze the dynamics of government purchases in an otherwise standard neoclassical growth model. This fills an important gap in the literature, because our paper does for one relatively large component of domestic aggregate demand what macroeconomics since the quantitative revolution (Kydland and Prescott, 1982) has done for private consumption and investment. In addition, we complement the work by Battaglini and Coate (2008b) by studying the business cycle dynamics of government purchases under a probabilistic voting and a majority voting environment.

We start from the representative household model in Klein et al. (2008) and add aggregate productivity shocks.[3] Like theirs our model features a government that cannot commit ex ante to a path of government purchases, but takes into account future streams of government purchases and how they depend on current decisions. The solution concept for the game between successive governments is the Markov perfect equilibrium. Government purchases are financed by income taxes. We abstract from government debt and transfers. Our first contribution is to compute and analyze such a model of time-consistent government policy in the presence of aggregate shocks. We find that it displays close to perfect positive correlation between aggregate output and government purchases. We also find too low persistence of the latter. Such a model can explain 58% of the observed volatility of government purchases. Notice that current government purchases in such a model are mainly determined by the intertemporal trade-offs between both private and government consumption today and tomorrow.

We then extend our model by three features: uninsurable idiosyncratic labor income risk that makes agents ex post heterogenous in their wealth holdings, heterogeneous discount factors as in Krusell and Smith (1997 and 1998) that generate a wealth distribution with quantitatively realistic inequality, and a wealth bias in the political decision making process. We show that these elements help the model to match several features of government purchases. We also demonstrate with the help of several numerical exercises that they are all necessary for this improvement. Specifically, we find that the contemporaneous correlation between output and government purchases drops below their dynamic correlation, while the persistence of government consumption increases, even above the level in the data. We show that a very unequal wealth and therefore income distribution – more unequal wealth leads to more unequal capital income – intensifies disagreement about the optimal level of government purchases. However, this itself is not sufficient to break the tight dynamic link between the cycle and government purchases. What is also needed is that this disagreement is funneled through political inequality. Following Benabou (2000), Bartels (2008) and Campante (2008), we achieve this by introducing a wealth bias into the political decision making process. We show that the more political influence increases with wealth, the more decoupling of the dynamics of output or

[3]For computational simplicity we abstract from endogenous labor supply.

private consumption and government purchases over the business cycle we find. For our preferred calibration we also demonstrate that the degree of wealth bias that matches the contemporaneous correlation between GDP and government purchases in the data is also broadly in line with the campaign contribution shares by income percentiles reported in Benabou (2000). This lends additional support for our mechanism. However, we also find that our preferred model can explain only 29% of the observed volatility of government purchases, half compared to the representative agent model. This means a tension between amplification and propagation/comovement with respect to government purchases as it pertains to the introduction of economic and political heterogeneity into the Klein et al. (2008) model.

Benabou (2000), Bartels (2008) and Campante (2008) all provide strong direct evidence of wealth bias in terms of political participation, including voter turnout, influence activities and campaign contribution. In contrast, we are interested in the identification of wealth bias from the *policy outcome data*. By providing an "estimate"of wealth bias in a fully dynamic structural model, we make inroads into a structural approach of identifying latent characteristics of the political process.[4] In addition, our quantitative characterization of effects of wealth bias complements the previous theoretical work on the implications of pro-wealth political institutions in Benabou (2000) and Bai and Lagunoff (2009, 2010).

This paper also makes three minor, but potentially more generally applicable contributions: we combine the algorithms in Krusell and Smith (1998) and Klein et al. (2008) and show that approximating the wealth distribution and its law of motion by a finite number of moments can also be applied to politico-economic equilibrium models with uninsurable labor income risk and aggregate shocks. Secondly, we provide a realistically calibrated, quantitative example with at least a small quantitative deviation from approximate aggregation in the sense of Krusell and Smith (1998). Indeed, our equilibrium laws of motion contain the Gini coefficient of the wealth distribution in addition to the average wealth. The Gini coefficient is a logical choice, given that wealth inequality together with wealth bias in political decision making directly determines the chosen level of government purchases at each point in time. We show that introducing this higher moment into the equilibrium laws of motion changes the equilibrium dynamics of the model, especially comovement between output and government purchases, if only somewhat. Finally, we extend the well-known result in the literature that political decision making via a standard unbiased utilitarian welfare function is equivalent to probabilistic voting (see Lindbeck and Weibull, 1987) to a dynamic set up and the case of wealth-biased probabilistic voting. Probabilistic voting describes a voting environment where agents are characterized by additional exogenous political preferences and two office-seeking static politicians maximizing the probability of winning.

[4] Bartels (2008) also provides estimates of wealth bias from policy outcomes, but his analysis relies on reduced-form statistical analysis.

Related Literature

In addition, our paper is also related to three other strands of the literature. Methodologically, we build on the framework developed in the large literature on dynamic political economy, e.g. Krusell, et al. (1997), Hassler et al. (2003), Hassler et al. (2005), Hassler et al. (2007), Song et al. (2007), Azzimonti et al. (2008), Azzimonti (2009), Corbae et al. (2009). Secondly, our paper is related to the incomplete markets literature with fiscal policy and aggregate shocks, such as Heathcote (2005) and Gomes et al. (2008), although there fiscal policy is treated exogenously. Thirdly, this paper complements the literature on procyclical fiscal policy in developing countries that focuses international aspects such as sovereign borrowing constraints and dysfunctional democracy (see Ilzetzki (2007), Alesina et al. (2008), and Ilzetzki and Vegh (2008) for an overview).

The remainder of the paper proceeds as follows: section two describes briefly the main stylized business cycle facts on government purchases that this paper seeks to explain. Section three explains the economic environment, the equilibrium concept, computation and calibration. Section four presents the results from numerical simulations and some robustness checks. Section five concludes. More business cycle facts about government purchases, numerical details and more simulation results are relegated to several appendices.

2 Some Stylized Facts

Table 1 displays the main business cycle facts for annual U.S. data from 1960-2006. Annual data on government purchases correspond closely to the yearly nature of government budgeting and therefore we focus on this frequency.[5] We included GDP, private consumption and private gross investment as well as two measures of government purchases on goods and services: government consumption and gross investment (G) including defense spending, and government non-defense consumption and gross investment (GND). Four stylized facts can be glanced from this table: first, government purchases are at least as volatile as aggregate output. Second, government purchases are the most persistent component of domestic aggregate demand. This is manifested both in the highest first-order autocorrelation coefficient, but also positive second-order autocorrelation coefficients, a rarity in annual economic data. Third, government purchases are the least procyclical component of domestic aggregate demand. In particular, private consumption expenditures are much more correlated with aggregate output than government purchases. This is also reflected in a relatively low correlation coefficient of govern-

[5]Quarterly data on government purchases display a low or zero contemporaneous correlation and then rise until a peak correlation around 6-8 quarters of GDP lagging today's G.

ment purchases with private consumption expenditures. Fourth, unlike aggregate output and all its other components, the dynamic correlations of government purchases with lagged output are higher than the contemporaneous correlations. In Appendix A we show a similar second moment analysis for more disaggregated components of government purchases. The second to fourth fact hold for most components of government purchases as well. The model in our preferred calibration can help us understand facts two, three and four: persistence, comovement, dynamic correlation. It generates 29% of the observed volatility of government purchases.

Table 1: BUSINESS CYCLE FACTS WITH GOVERNMENT PURCHASES

Moment	Y	C	I	G	GND
St. dev.	1.90%	1.67%	7.84%	2.81%	1.87%
Autocorrel. 1st-order	0.54	0.62	0.42	0.79	0.74
Autocorrel. 2nd-order	-0.02	0.09	-0.16	0.38	0.27
Correl. w. Y	1	0.87	0.84	0.35	0.47
Correl. w. Y-Lag.	0.54	0.41	0.21	0.51	0.58
Correl. w. C	0.87	1	0.69	0.35	0.49

Notes: Y denotes GDP, C private consumption expenditures, I private gross fixed investment, G government consumption and gross investment expenditures, GND government non-defense consumption and gross investment expenditures. All variables are annual, they range from 1960-2006. They are deflated by their corresponding deflators, logged and filtered with a Hodrick-Prescott filter with smoothing parameter 100.

3 The Model

The economic environment is a standard heterogeneous household stochastic growth model, as in Krusell and Smith (1998). In the economy, households face idiosyncratic shocks to labor efficiency and to their discount factor to which they partially insure using physical capital as the only asset. This leads to idiosyncratic labor income risk. We add a government that taxes households' incomes and adheres to a balanced budget rule. The government cannot commit ex ante to a stream of government purchases. Government purchases are determined through maximizing a social welfare function period-by-period. Following Klein et al. (2008), we study Markov-perfect equilibria of such an economy.

3.1 The Economic Environment

The economy is populated by a continuum of ex-ante identical, infinitely lived households with a unit mass $i \in [0,1]$. In each period, the household i values a homogenous, perishable private consumption good, c_i, and government purchases, G, according to the following felicity function:

$$u(c_i, G) = \theta \log(c_i) + (1-\theta)\log(G). \tag{1}$$

The life time utility follows the standard expected utility form with a discount factor β_i. The household does not value leisure and is endowed with $\tilde{l}$ units of time, which she supplies inelastically in a competitive labor market.

There are two sources of heterogeneity: households receive persistent idiosyncratic shocks to their labor efficiency, ϵ_i, and to their discount factor, β_i. We assume that both ϵ_i and β_i evolve according to discrete Markov chains, and ϵ_i and β_i are independent of each other. Idiosyncratic labor efficiency shocks are a standard assumption in the incomplete markets literature (see, e.g., Huggett, 1993, and Aiyagari, 1994), because they give rise to a non-degenerate wealth distribution. Discount factor heterogeneity is used by Krusell and Smith (1997, 1998) to quantitatively match the shape of the U.S. wealth distribution. We employ the same device and show that matching the inequality in the U.S. wealth distribution is crucial for understanding the dynamics of government purchases in our model.

Household i owns capital, k_i, and rents it out in a perfectly competitive market. Capital depreciates at rate δ. The budget constraint of the household i is given by:

$$c_i + k_i' = (1-\delta)k_i + (1-\tau)\left(w\tilde{l}\epsilon_i + rk_i\right), \tag{2}$$

where k_i' is capital carried over to the next period, τ the flat income tax rate, w the real wage and r the rental rate for capital. k_i' is restricted to lie in $[\underline{k}, +\infty)$.[6]

Aggregate output, Y, is produced by a representative firm according to an aggregate Cobb-Douglas production function: $Y = zK^{\alpha}L^{1-\alpha}$, where $K = \int_0^1 k_i di$ and $L = \tilde{l}\int_0^1 \epsilon_i di$ are aggregate capital stock and efficiency labor, respectively. Since ϵ_i is uncorrelated across households, L is a constant owing to the law of large numbers. z is an aggregate productivity shock and the only source of aggregate uncertainty in this economy. It evolves again according to a discrete Markov chain, which is independent from the two Markov processes that govern the idiosyncratic stochastic environment. The firm rents capital and hires labor from the household at the rental rate r and wage rate w. Competitive factor markets guarantee the usual factor price conditions: $w(K,z) = (1-\alpha)(K/L)^{\alpha}$ and $r(K,z) = \alpha z (K/L)^{\alpha-1}$.

[6] If $\underline{k} < 0$, k_i is not literally physical capital. We follow here Krusell and Smith (1998) and use $\underline{k}$ to target the fraction of negative net wealth holders in the U.S.

In the aggregate, the economy faces a standard one-sector resource constraint:

$$C+G+K'=(1-\delta)K+zK^{\alpha}L^{1-\alpha}. \tag{3}$$

3.2 Equilibrium with Endogenous Public Policy

The income tax rate, τ, and government purchases, G, are chosen by the government. In choosing these policies, the government faces three institutional constraints. The first one is a balanced budget requirement.[7] Since total income equals total output in the aggregate, the balance-budget constitution defines the income tax rate as a function of (K,z,G):

$$\tau(K,z,G)=\frac{G}{zK^{\alpha}L^{1-\alpha}}. \tag{4}$$

With the function $\tau(K,z,G)$, the government policy problem in each period is reduced to the choice of G, a one-dimensional object.

Second, the government chooses G under the constraints of social choice institutions. Some examples of social choice institutions are the utilitarian social planner and a major voting mechanism, although we are going to study more flexible mechanisms in the next subsection. For the purpose of defining an equilibrium, however, we present the constraint as an abstract social preference aggregator, $W\left(\{J_i\}_{i\in[0,1]}\right)$, which maps the preferences of each household, J_i, to the equilibrium choice. J_i denotes in net present value terms the indirect utility function of each household over alternative policy proposals. It is formally defined below.

Finally, the government cannot commit to a stream of future policies. Without a commitment device, it is well known that the commitment equilibrium in our environment is not time-consistent. Time consistency requires imposing a subgame-perfect restriction with successive governments and the households as game players. Following Krusell and Rios-Rull (1999) and Klein et al. (2008), we focus on a subclass of subgame-perfect equilibrium with Markov strategies, i.e., Markov-Perfect Equilibrium (MPE).[8] Adapted to our heterogeneous agent environment, the aggregate state variables consist of the technology shock, z, and the joint distribution over the pair $\left(k_i,\epsilon_i,\beta_i\right)$, denoted by Γ. With the choice of these state variables, the MPE is defined in terms of continuation value functions and best response functions under a one-shot deviation. Loosely speaking, MPE is achieved if these objects satisfy standard requirements of

[7] To avoid a two-dimensional policy space and thus to keep the model tractable we abstract from government debt and leave this for future research.

[8] By construction, this class of Markov Perfect Equilibrium rules out the reputational equilibria with history-dependent strategies. For examples of equilibria with trigger strategy and reputation, see Aguiar and Amador (2009). For studies of constrained efficient policies with political economy frictions, see Acemoglu, Golosov and Tsyvinski (2009) and Farhi and Werning (2008).

Recursive Competitive Equilibrium (RCE) on the equilibrium path, and best-response consistency on the off-equilibrium path.[9] Because the behavior on the equilibrium path follows the standard RCE concept (e.g., as in Krusell and Smith (1998)), we mainly focus on the Markov-Perfect aspect of the equilibrium. The formal definition follows.

Definition 1 *A Markov-Perfect Equilibrium for the economy is a set of functions, including a government policy function* $G = \Psi(\Gamma, z)$*, a distribution transition function* $\Gamma' = H(\Gamma, z, G)$*, an equilibrium continuation value function* $v(k,\epsilon,\beta,\Gamma,z;\Psi,H)$*, a best-response value function* $J(k,\epsilon,\beta,\Gamma,z,G;\Psi,H)$ *and a best-response decision rule* $k' = h(k,\epsilon,\beta,\Gamma,z,G;\Psi,H)$*, such that*

(a) For any given G*, the functions* $J(k,\epsilon,\beta,\Gamma,z,G;\Psi,H)$*,* $v(k,\epsilon,\beta,\Gamma,z;\Psi,H)$ *and* $h(k,\epsilon,\beta,\Gamma,z,G;\Psi,H)$ *solve the household problem*

$$\begin{aligned} J(k,\epsilon,\beta,\Gamma,z,G;\Psi,H) &= \max_{\{c,k'\}} \left\{ u(c,G) + \beta E\left[v(k',\epsilon',\beta',\Gamma',z';\Psi,H) \mid \epsilon, z \right] \right\} \\ & s.t. \\ & c \geq 0, k' \geq \underline{k}, \\ & c + k' = (1-\delta)k + (1-\tau(K,z,G))\left(w(K,z)\tilde{l}\epsilon + r(K,z)k\right), \\ & \Gamma' = H(\Gamma,z,G). \end{aligned}$$

In addition, $v(k,\epsilon,\beta,\Gamma,z;\Psi,H) = J(k,\epsilon,\beta,\Gamma,z,\Psi(\Gamma,z);\Psi,H)$*.*

(b) $H(\Gamma,z,G)$ *is implied by* $h(k,\epsilon,\beta,\Gamma,z,G;\Psi,H)$ *and the exogenous stochastic processes.*

(c) $\Psi(\Gamma,z)$ *is a result of social choice, i.e.,* $\Psi(\Gamma,z) = W\left(\left\{J(k_i,\epsilon_i,\beta_i,\Gamma,z,G;\Psi,H)\right\}_{i\in[0,1]}\right)$*.*

The first part of the equilibrium definition says that h is the best response of the household to an arbitrary change in current G when the future follows the equilibrium path, a so called one-shot deviation best response. J denotes the corresponding value function. In addition, the best-response value function should coincide with the equilibrium continuation function when evaluated at the equilibrium policy $G = \Psi(\Gamma,z)$. The second part requires that the evolution of the aggregate distribution, $H(\Gamma,z,G)$, is generated by the households' best responses for any given G and the exogenous stochastic processes. This reflects rational expectation on the household side. On the equilibrium path, this requirement reduces to the familiar consistency restriction in RCE. In addition, MPE imposes the same requirement for off-equilibrium paths. The third part imposes the constraint from the social choice institution.

Notice that when there is only a representative type of household who faces aggregate shocks, our economy reduces to a stochastic growth version of Klein et al. (2008).

[9] This corresponds to the formulation of MPE in Klein et al. (2008).

3.3 Social Choice Mechanisms

In our baseline model, the public choice mechanism is defined as

$$\Psi(\Gamma, z) = \arg\max_{G} \left\{ \int_0^1 (k_i^+)^{\chi} \, J\left(k_i, \epsilon_i, \beta_i, \Gamma, z, G; \Psi, H\right) di \right\}, \tag{5}$$

where $\chi \in \mathbb{R}$ is a given institutional parameter reflecting characteristics of the political process and $k_i^+ \equiv \max[0, k_i]$.[10] The government chooses public policy so as to maximize a weighted social welfare function, with weights dependent on the wealth of the households. The weighting function, $(k_i^+)^{\chi}$, is meant to be a flexible reduced form to capture wealth bias in the political process. If $\chi = 0$, every household is treated equally, which leads to the familiar egalitarian social welfare function. A positive (negative) value of χ implies a pro-wealth (anti-wealth) bias in the political process. As the absolute value of χ increases, the degree of wealth bias becomes larger.

The choice of a wealth-dependent weighting function is motivated by the documented pro-wealth bias in the U.S. political process. For example, Benabou (2000) presents patterns of political participation, including voter turnout rates, campaign contributions, and influence activities among different groups of the income distribution. He finds that the propensity to participate in every reported form of political activities rises with income. In a systematic study using Senators' voting records, Bartels (2008) finds that Senators are unresponsive to the preferences of lower income groups.

There are different interpretations of our baseline public choice mechanism. From a normative aspect, the weighted social welfare function approach can be viewed as a social planner's problem. As we shall see in the next subsection, there is also a micro-founded positive interpretation, which is generated by a political process in a probabilistic voting environment. There the weighting function, $(k_i^+)^{\chi}$, can be attributed to a pro-wealth vote allocation in a weighted voting system. We thus extend the well-known result in the literature that political decision making via a standard unbiased utilitarian welfare function is equivalent to probabilistic voting (see Lindbeck and Weibull, 1987) to a dynamic set up and the case of wealth-biased probabilistic voting.

3.3.1 A Probabilistic Voting Interpretation

As in the standard probabilistic voting environment, there are two political candidates competing for office. Both candidate A and B are office-seeking with the only objective to maximize

[10] See Benabou (2000) and Bai and Lagunoff (2009). Using k_i^+ is a convenient way to avoid negative weights in the welfare function. We also experimented with a weighting function that depends on total available resources, $(k_i - \underline{k})^{\chi}$, and found that the results are not dependent on this functional form.

their probability of winning. The politicians live for one period and hence are static decision makers. But they have to take into account the dynamic utility of the voters to maximize their winning probability.

Following Lindbeck and Weibull (1987), we introduce an idiosyncratic, σ, and an aggregate, d, element of uncertainty in the political dimension. Both σ and d are uniformly distributed random variables and i.i.d. across time, with support $\sigma \in \left[-\frac{1}{2\phi_\sigma}, \frac{1}{2\phi_\sigma}\right]$ and $d \in \left[-\frac{1}{2\phi_d}, \frac{1}{2\phi_d}\right]$. σ and d represent the political advantage of candidate B relative to candidate A. With this new political dimension every voter ij is identified by $(k_i, \epsilon_i, \beta_i, \sigma_j)$. More specifically, σ_j can be interpreted as the realized idiosyncratic "ideology" advantage parameter, for example utility towards issues like abortion, same-sex marriage, etc. d is interpreted as the aggregate "popularity" parameter, for example personal charisma, etc. Both σ and d are known to the voters, but they are not known to the politicians. Since σ is a purely idiosyncratic component, it does not introduce any de facto uncertainty from the point of view of candidates. But d presents true uncertainty for political candidates, which is a crucial mechanism in a probabilistic voting model.

The felicity function of household ij under policy of the candidate B (G_B) is assumed to be

$$u(c_i, G_B) + \sigma_j + d.$$

Taking expectations over future felicity streams and using the iid nature of σ and d, yields the following best-response value function:

$$J\left(k_i, \epsilon_i, \beta_i, \Gamma, z, G_B; \Psi, H\right) + \sigma_j + d.$$

Under candidate A this is given by $J\left(k_i, \epsilon_i, \beta_i, \Gamma, z, G_A; \Psi, H\right)$. Given any value of d (which is unknown to the candidate), the "swing voter" within an economic type $(k_i, \epsilon_i, \beta_i)$ is associated with an ideology threshold, $\hat{\sigma}_i$, such that

$$\hat{\sigma}_i\left(k_i, \epsilon_i, \beta_i, \Gamma, z, G_A, G_B; \Psi, H\right) = J_i{}^A - J_i{}^B - d,$$

where $J_i{}^s = J_i\left(k_i, \epsilon_i, \beta_i, \Gamma, z, G_s; \Psi, H\right)$, $s \in \{A, B\}$. Any political type within economic type $(k_i, \epsilon_i, \beta_i)$ with $\sigma_j < \hat{\sigma}_i$ will vote for policy G_A and vice versa. As a result, the vote share for candidate A from economic type $(k_i, \epsilon_i, \beta_i)$ is $\phi_\sigma \cdot \left(J_i{}^A - J_i{}^B - d\right) + \frac{1}{2}$.

Following Benabou (2000) and Bai and Lagunoff (2009), let $\lambda(k_i) = (k_i^+)^\chi$ denote the number of votes allocated to each member of economic group $(k_i, \epsilon_i, \beta_i)$. In a standard one-person-one-vote system, $\lambda(k_i) = 1$. In a one-dollar-one-vote system, $\lambda(k_i) = k_i^+$.

The total vote share for policy G_A for a given popularity d is therefore

$$\pi_A(d) = \frac{\phi_\sigma \int_0^1 (k_i^+)^\chi \left({J_i}^A - {J_i}^B\right) di}{\int_0^1 (k_i^+)^\chi di} - \phi_\sigma d + \frac{1}{2}.$$

The expected winning probability (given the uncertainty from d) is therefore

$$\begin{aligned} & \Pr\left(\pi_A(d) > \frac{1}{2}\right) \\ = & \Pr\left(\frac{\int_0^1 (k_i^+)^\chi \left({J_i}^A - {J_i}^B\right) di}{\int_0^1 (k_i^+)^\chi di} > d\right) \\ = & \frac{\phi_d}{\int_0^1 (k_i^+)^\chi di} \int_0^1 (k_i^+)^\chi \left({J_i}^A - {J_i}^B\right) di + \frac{1}{2}. \end{aligned}$$

Because of the separability of ${J_i}^A$ and ${J_i}^B$, for any G_B, a dominant strategy for candidate A is to maximize

$$\int_0^1 (k_i^+)^\chi {J_i}^A di,$$

i.e., a utilitarian social welfare function with weighting parameters $(k_i^+)^\chi$. By symmetry, type B maximizes the same social welfare function. Consequently, both candidates will share the same objective and propose the same policy.

3.3.2 Weighted Majority Voting Environment

As a robustness check, we also study in Section 4.4 a pairwise majority voting environment, with vote allocation for type $(k_i, \epsilon_i, \beta_i)$ equal to $(k_i^+)^\chi$.[11] As in a standard majority voting environment, the policy with fifty percent of the votes will be the winner if the preference of every household is well-ordered. [12] More specifically, let $\widehat{G}\left(k, \epsilon, \beta, \Gamma, z; \Psi, H\right) = \arg\max_G J\left(k, \epsilon, \beta, \Gamma, z, G; \Psi, H\right)$ be the preferred policy of economic type $\left(k, \epsilon, \beta\right)$. Then the Cordorcet winner in a weighted majority voting system is $\left(k^*, \epsilon^*, \beta^*\right)$ such that

$$\frac{\int_{\{i:\widehat{G}(k_i,\epsilon_i,\beta_i) < \widehat{G}(k^*,\epsilon^*,\beta^*)\}} (k_i^+)^\chi di}{\int (k_i^+)^\chi di} = \frac{1}{2}.$$

[11] Of course, this case does not fall under the social welfare function case at the beginning of this subsection, see Equation(5). But it is covered by the general social preference aggregator, $W\left(\{J_i\}_{i\in[0,1]}\right)$.

[12] In the voting literature, there are different sufficient conditions to guarantee the existence of the voting equilibrium, e.g., single-peakedness, intermediate preference and single crossing conditions (see Persson and Tabellini, 2000, for an overview). Although there are general existence results for the complete-market neoclassical growth model with policy commitment(see Bassetto and Benhabib, 2006), we are not aware of similar results applicable to our environment. Nevertheless, we verify numerically that single-peakedness is always satisfied in our computation.

3.4 Computation

As our question is fundamentally quantitative, we use numerical methods to characterize and analyze the Markov-Perfect equilibrium. In computing the equilibrium, we face the usual practical challenge introduced by the heterogeneous agent economic environment, as well as new complications due to the endogenous economic policy determination.

On a conceptual level, we need to adapt the fixed-point iteration procedure used in computing RCE to account for the best-response consistency of off-equilibrium paths. As already intimated in our equilibrium definition, our procedure iterates on the best response transition function and policy function (H,Ψ) to reach a fixed point. In doing this, both on and off equilibrium restrictions are honored in every step of the computation.

On a practical level, we have to specify a set of moments of the wealth distribution and functional forms for (H,Ψ) to implement the general procedure proposed in Krusell and Smith (1998). Recall that Krusell and Smith use a finite number of summary statistics to approximate the infinite-dimensional object of the wealth distribution and its law of motion. In their implementation, they find that average capital is sufficient to forecast future prices. However, because of the public choice nature of fiscal policy, there are strong reasons to believe that other higher-order statistics matter for the evolution of the economy. Indeed, this intuition is verified in our simulations. We find that the combination of average capital and the Gini coefficient of the capital distribution is sufficient to characterize the evolution of our economy, yet at the same time keeps the dimensionality of the problem tractable.[13] The Gini coefficient directly characterizes wealth inequality, which we will show to generate in conjunction with political inequality the distinct features of the dynamics of aggregate government purchases we discussed in Section 2. Specifically, the computed fixed point of H takes the form of the following Krusell-Smith (KS) rules:[14]

$$\log K' = a_0(z) + a_1(z)\log K + a_2(z)\log Gini(k) + a_3(z)\log G + a_4(z)\left(\log G\right)^2, \quad (6)$$

$$\log Gini(k') = \widetilde{a}_0(z) + \widetilde{a}_1(z)\log K + \widetilde{a}_2(z)\log Gini(k) + \widetilde{a}_3(z)\log G + \widetilde{a}_4(z)\left(\log G\right)^2, \quad (7)$$

and that of Ψ takes the form of

$$\log G = b_0(z) + b_1(z)\log K + b_2(z)\log Gini(k). \quad (8)$$

Notice that these functions depend on the discrete level of aggregate productivity.

[13] We also experimented with the standard deviation of the wealth distribution, but found better R2 improvements with the Gini coefficient. In addition, the Gini coefficient, a measure of wealth inequality, represents our politico-economic mechanism directly.

[14] It turns out that $\left(\log G\right)^2$ improves the fit of the law of motion for capital significantly.

Computational Algorithm

We solve the MPE using a fixed point iteration procedure from (H,Ψ) onto itself. The algorithm can be summarized as follows:

Algorithm 1 *Fixed Point Iteration on* (H,Ψ)
Step 0: Select a set of summary statistics of the wealth distribution $(K, Gini(k))$ *and fix the functional form. Start from an initial guess of coefficients* $\{a_0^0,\ldots,a_4^0\},\{\tilde{a}_0^0,\ldots,\tilde{a}_4^0\},\{b_0^0,\ldots,b_2^0\}$ *to get initial conjectured functions* $\left(H^0,\Psi^0\right)$*. Set up a convergence criterion* ε*.*
Step 1: In step n, imposing (H^n,Ψ^n) *in the best-response optimization problem, use value function iteration to solve for the household's parametric dynamic programming problem. Get the continuation value function* $v^n\left(k,\epsilon,\beta,\Gamma,z;\Psi^n,H^n\right)$*.*
Step 2: Without imposing Ψ^n *and instead varying G freely on a finite grid, use* H^n *and* $v^n\left(k,\epsilon,\beta,\Gamma,z;\Psi^n,H^n\right)$ *to solve for the best-response value function* $J^n\left(k,\epsilon,\beta,\Gamma,z,G;\Psi^n,H^n\right)$ *and decision rule* $h^n\left(k,\epsilon,\beta,\Gamma,z,G;\Psi^n,H^n\right)$*.*
Step 3: Simulate the economy using N_H *households and T periods. In each period t of the simulation, calculate the equilibrium policy* $G_t^{eq.}$ *using* $J^n\left(k,\epsilon,\beta,\Gamma,z,G;\Psi^n,H^n\right)$ *and the social choice rule. Calculate the best response decision based on* $h^n\left(k,\epsilon,\beta,\Gamma,z,G;\Psi^n,H^n\right)$ *for both equilibrium* $G_t^{eq.}$ *and pre-specified* N_G *grid points of G,* $\left(G_{t,i}\right)_{i=1}^{N_G}$*. Gather a time series of* $\left(K_{t+1}^{eq.},\left(K_{t+1,i}\right)_{i=1}^{N_G},Gini_{t+1}^{eq.},\left(Gini_{t+1,i}\right)_{i=1}^{N_G},G_t^{eq.},\left(G_{t,i}\right)_{i=1}^{N_G}\right)_{t=1}^{T}$*, i.e. capital statistics both on (*$K_{t+1}^{eq.}$*) and off-equilibrium path* $\left(\left(K_{t+1,i}\right)_{i=1}^{N_G}\right)$*, with a total sample size of* $T(1+N_G)$*.*
Step 4: Use gathered time series to get – separately for each value of the z-grid – OLS estimates of $\{\hat{a}_0^n,\ldots,\hat{a}_4^n\},\{\hat{\tilde{a}}_0^n,\ldots,\hat{\tilde{a}}_4^n\},\{\hat{b}_0^n,\ldots,\hat{b}_2^n\}$*, which with a slight abuse of notation we summarize as* $\left(\hat{H}^n,\hat{\Psi}^n\right)$*. Notice that obviously* $\hat{H}^n$ *is updated on both the on- and off-equilibrium paths,* $\hat{\Psi}^n$ *only on the on-equilibrium path.*
Step 5: If $|H^n-\hat{H}^n|<\varepsilon$ *and* $|\Psi^n-\hat{\Psi}^n|<\varepsilon$*, stop. Otherwise, set*

$$
\begin{aligned}
H^{n+1} &= \alpha_H\times\hat{H}^n+(1-\alpha_H)\times H^n,\\
\Psi^{n+1} &= \alpha_\Psi\times\hat{\Psi}^n+(1-\alpha_\Psi)\times\Psi^n,
\end{aligned}
$$

with $\alpha_H,\alpha_\Psi\in(0,1]$*, and go to step 1.*
Step 6: Check whether the R2 of the final OLS regressions are high enough to convey confidence that the true equilibrium rule is well approximated. Otherwise go to step 0. [15]*.*

[15]We chose $\varepsilon=10^{-4}$, $N_H=30{,}000$, $T=1{,}500$, of which we discard the first 500, when we update the KS-rules or compute summary statistics. Following Krusell and Smith (1998), we also make sure that these 30,000 agents are always distributed according to the stationary distributions of the Markov chains that govern ϵ and β, and thus avoid introducing artificial aggregate uncertainty owing to the small deviation from the law of large numbers. To eliminate sampling error, we use the same series of aggregate shocks for all iterations and all model simulations.

3.5 Calibration

In this subsection we discuss the baseline calibration of the model described above. The model is calibrated to match important features of the U.S. economy from 1960 to 2006. Annual data on government purchases correspond closely to the yearly nature of government budgeting and therefore we calibrate our model to this frequency. This choice implies three immediate parameter selections: the depreciation rate, δ, is set to 0.1; the discount rate, β, is centered around 0.96.[16] We finally model aggregate productivity, z, as a five-state Markov chain that approximates a log-AR(1) process with an autocorrelation coefficient of 0.8145[17] and conditional standard deviation of 0.0165. This standard deviation is chosen to make our models approximately match the annual percentage standard deviation of GDP in the data, 1.90%. It turns out that the models we will be looking at behave all very similarly in terms of output dynamics, which is why we fix this number throughout. This paper is not concerned with explaining output volatility from a measured exogenous shock series, as the RBC tradition, which uses fluctuations in the Solow residual to generate a large part of observed output fluctuations. Rather, this paper is about explaining government purchases dynamics (and other components of aggregate demand), given the correct output dynamics. An alternative approach would be to study standard deviations of the components of aggregate demand relative to the one of output. The final standard parameter is the output elasticity of capital, $\alpha = 0.36$.

Idiosyncratic labor efficiency, ϵ, is modeled as a nine-state Markov chain that approximates a log-AR(1) process with an autocorrelation coefficient of 0.75 and conditional standard deviation of 0.18. These numbers are broadly consistent with the estimates from Guvenen and Smith (2008) who use an indirect inference approach and data on labor income, labor supply and consumption to estimate a model for the natural logarithm of labor income.[18] We set $\tilde{l} = 0.33$.

We also assume that the discount factor evolves according to a very persistent three-state Markov chain that is pinned down by four conditions: 1) at every point in time the majority of the population (80%) occupies the middle $\beta = 0.96$, and the very patient and very impatient agents have a mass of 10% each; 2) the average duration of a given discount factor is 50 years, which is meant to capture a dynastic element in this infinite horizon model; 3) agents do not jump over a state; 4) the equidistant difference between the three grid points is calibrated jointly with the borrowing constraint, $\underline{k}$, to be broadly consistent with the fraction of households with negative wealth in U.S. data and the Gini coefficient of the U.S. wealth distribution. This calibration strategy as well as its targets[19] is taken from Krusell and Smith (1998) and adapted to the annual frequency. We find that given the above labor income process that does not feature an

[16] In fact, when we look at cases with a deterministic discount rate we fix it at 0.96.

[17] 0.95 to the power of four.

[18] In our model, ϵ is not quite labor income, but we checked numerically that the stochastic properties of ϵ are inherited by $w\tilde{l}\epsilon$.

[19] 11% for the fraction of negative net wealth holders and 0.79 for the Gini coefficient.

unemployment state, a small borrowing constraint of 0.01 and the following grid for β is broadly consistent with the calibration targets across all models: $[0.94, 0.96, 0.98]$. Appendix B displays the exact specifications of these three Markov chains.

Two parameters remain to be calibrated: θ, the love-of-government-purchases parameter in the felicity function; and χ, the exponent in the wealth-weighting function in the political aggregation mechanism. For θ we adopt the following baseline strategy: for each model, given the set of parameters above and a value for χ, we choose θ so that the model matches the time-averaged $\frac{G}{Y}$-ratio that is based on aggregate non-defense government purchases, GND. We thus follow the large empirical literature that views only defense government purchases as a truly exogenous stochastic process and uses this assumption for the identification of the economic consequences of exogenous government spending shocks. Of course, since this paper is about endogenous government purchases we simply take the complement, i.e. non-defense government purchases. We check for robustness of this target choice in Section 4.4. For χ we take no a priori stance and rather conduct scenario analyses, where we vary χ parametrically. We do, however, argue that the political inequality of our preferred model, implied by its χ-value, is broadly in line with the data provided by Benabou (2000).

4 Results

We present the results of our numerical simulations in four steps: we first analyze an environment without heterogeneity. To this end, we investigate the business cycle properties of our model, when idiosyncratic labor efficiency and the discount factor are set to constant values. Specifically, we normalize idiosyncratic labor efficiency to unity and set the discount factor to its middle value of 0.96. We find that such an economy produces counterfactual government purchases dynamics. Specifically, output and government purchases comove too much over the cycle. We show that this result holds whether we assume decision and implementation lags or not. We then present a similar environment with income and wealth heterogeneity and wealth bias in the political decision mechanism and show that this lowers comovement and delivers higher persistence of government purchases, while lowering their volatility further away from what we find in the data. We thus find that their is a tension between propagation and amplification with respect to government purchases when we introduce heterogeneity and wealth bias. In a third step we explain this result with the help of several numerical exercises. In a fourth step we show robustness of our results to calibrating the model to a higher $\frac{G}{Y}$-ratio and to using wealth-weighted majority voting as the political aggregation mechanism.

4.1 The Representative Household Case

In this subsection, we start with the representative household case. Table 2 displays the business cycle statistics of endogenously determined government purchases from model simulations where we abstract from any heterogeneity.[20] Other business cycle statistics can be found in Table 17 in Appendix D. They are the usual real business cycle results. As has been explained in Section 3.2, abstracting from heterogeneity means that our model is simply the model from Klein et al. (2008) with aggregate uncertainty.[21]

Table 2: BUSINESS CYCLE STATISTICS OF GOVERNMENT PURCHASES - REPRESENTATIVE HOUSEHOLD SIMULATION

Moment	No Lag	Lag	Data
G			
St. dev.	1.08%	1.13%	1.87%
Autocorrel. 1st-order	0.62	0.61	0.74
Autocorrel. 2nd-order	0.25	0.23	0.27
Correl. w. Y	0.96	0.43	0.47
Correl. w. Y-Lag.	0.66	0.97	0.58
Correl. w. C	0.98	0.70	0.49
C			
Autocorrel. 1st-order	0.69	0.68	0.62
Autocorrel. 2nd-order	0.34	0.32	0.09
Correl. w. Y	0.90	0.92	0.87

Notes: G refers to government non-defense consumption and gross investment expenditures, C to private consumption expenditures. All variables are logged and filtered with a Hodrick-Prescott filter with smoothing parameter 100. The simulation numbers come from a simulation of 1500 periods, where the first 500 periods were discarded. "No Lag" refers to a simulation, where the political process decides about current government purchases. "Lag" refers to a simulation, where the political process decides about government purchases one year ahead. All simulations use the same series of aggregate shocks.

In the first column we show results under the assumption that government purchases are chosen without decision or implementation lags. Private consumption and government consumption are chosen concurrently. The first result is that a representative household model with aggregate technology shocks that fully explain output fluctuations can explain 58% of the observed volatility of government (non-defence) purchases. The second result is that government purchases are less persistent than private consumption in the model simulation, whereas

[20] The θ necessary to reach the target $\frac{G}{Y}$-ratio of roughly 0.15 is 0.78. In the equilibrium computation we use the same functional forms for the laws of motion as specified in equations(6)-(8) for the full model, without, of course, the Gini coefficient of the wealth distribution as a summary statistic. The coefficients for the KS rules and the $R2$ can be found in Tables 14 to 16 in Appendix C.

[21] They also feature an endogenous labor/leisure choice, from which we abstract here.

the opposite holds in the data, measured both in terms of first- and second-order autocorrelation. In particular, when measured in terms of the first-order autocorrelation coefficient, government purchases display less persistence than in the data. Apparently, the representative agent model lacks a strong propagation mechanism with respect to government purchases. The third result concerns comovement: government purchases comove almost perfectly with output and private consumption, which is at odds with the data. Put differently, government and private consumption have about the same comovement properties with output in the model, whereas government purchases are less synchronized with the overall cycle in the data.

In order to test, whether this excess synchronization is an artifact of abstracting from decision and implementation lags in the political process, we simulated a version of the same representative household economy, where the political process decides about next period's government purchases, rendering current government purchases an additional state variable of the economy.[22] This obviously solves the problem of the contemporaneous correlations of government purchases with GDP and private consumption, rendering the former 0.43, which is close to the 0.47 in the data. However, this also comes, perhaps not surprisingly, at the cost of an oversynchronization (relative to the data) with lagged output. As far as the other second moments are concerned, the case with lags behaves very similarly to the case without lags. We conclude from this analysis that a standard neoclassical growth model with aggregate technology shocks and Markov-perfect political decision making, i.e. a model environment, where current government purchases are mainly determined by the intertemporal trade-offs between both private and government consumption today and tomorrow, can explain important aspects of the observed dynamics of government purchases. But it also exhibits low propagation and excess comovement with the aggregate economy.[23] In the next section, we will argue that a model that features realistic wealth heterogeneity and a wealth-bias in political decision making, which opens up the possibility of political disagreement, can help us bring the model closer to the data at least in terms of comovement and persistence. Of course, another possibility to improve the model's performance would be to introduce additional shocks – to the preferences for government purchases, for instance – to increase persistence and break oversynchronization. We pursue this angle in other research.

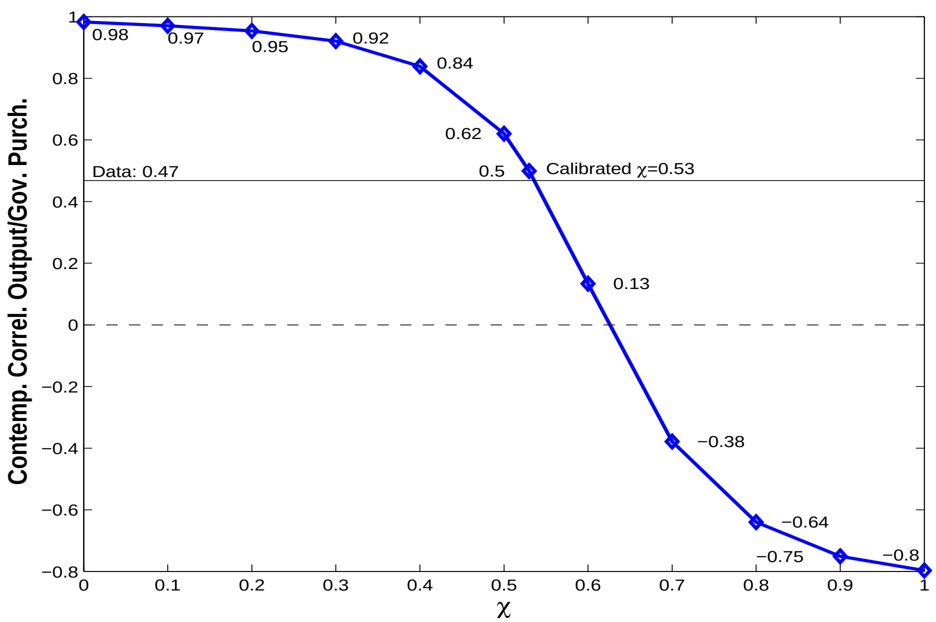
[22]We changed equations(6)-(8) accordingly, using the natural logarithm of G as an additional moment. The recalibrated θ is 0.785.

[23]We also tried a more general felicity function and moved away from the unit-elasticity of substitution specification in (1): $u(c_i, G) = \log\left(\theta c_i^{1-\rho} + (1-\theta)G^{1-\rho}\right)^{\frac{1}{1-\rho}}$. We experimented with $\rho = 0.5$ and $\rho = 2$ (and θ recalibrated to 0.655 and 0.93, respectively) with virtually the same aggregate dynamics as in the unit-elasticity case.

4.2 The Full Model

The preceding section has shown that the largest discrepancy between the data and the representative household model lies in the excess contemporaneous comovement between government purchases and output. In this section, we investigate the heterogeneous household version of our model that features a quantitatively realistic wealth distribution and probabilistic voting (equivalently a social welfare function) as the political aggregation mechanism. This is our baseline specification. In the heterogeneous agent version we abstract from decision and implementation lags with respect to government purchases, mainly for computational reasons to save on one state variable. We start out by illustrating how increases in the wealth bias in the political decision mechanism, which are parameterized by χ, the exponent in the political weight function, lead to a progressive decoupling of government purchases and output.

Figure 1: Correlation Between Y and G as a Function of Wealth Bias in the Baseline Calibration



Notes: In the simulations, all variables are logged and filtered with a Hodrick-Prescott filter with smoothing parameter 100. The simulation numbers come from a simulation of 1500 periods, where the first 500 periods were discarded. The simulation is started from an arbitrary initial wealth distribution. All simulations use the same series of aggregate shocks.

Figure 1 displays this effect: starting from the case with no wealth bias in the social welfare function – every agent in the economy has the same political weight – we increase χ and plot the contemporaneous correlation coefficient between output and government purchases from each of these model simulations.[24]

[24]We recalibrate for each value of χ, the felicity parameter on government purchases, θ, to match the target $\frac{G}{Y}$-

We find that at a value of $\chi = 0.53$ the model matches the observed contemporaneous co-movement between government purchases and output almost exactly. We will take this specification as our favorite model and analyze it more closely.[25] Before this, we provide some additional evidence on the degree of wealth or rather income bias in the U.S. political system. To this end, we compute time-averaged weight-shares in the social welfare function of our baseline case for the five income percentiles for which Benabou (2000) reports participation shares: $[0-16\%, 17-33\%, 34-67\%, 68-95\%, 96-100\%]$.[26] Table 3 compares these weight-shares in the social welfare function of our baseline case with the campaign contribution shares in the data. They can be interpreted as follows: 3.8% of all contributors come from the lowest income percentile, 15.4% from the highest one. It is apparent that the political bias towards high income agents in our model at least broadly lines up with the political bias exhibited in the measured campaign contribution shares. Relative to these our baseline calibration exhibits slightly larger political inequality. However, these measured campaign contribution shares most likely understate political inequality, given that they do not take into account the size of the contributions made by the different income groups. High income percentiles are likely to make larger contributions and thus “buy”more political influence.

Table 3: PARTICIPATION SHARES

Income Percentile	[0 – 16%]	[17 – 33%]	[34 – 67%]	[68 – 95%]	[96 – 100%]
Weight shares - Baseline Model	2.9%	7.2%	25.6%	41.7%	22.6%
Campaign contribution shares	3.8%	8.2%	31.6%	40.9%	15.4%

Notes: "Baseline" refers to the heterogeneous agent model with wealth bias parameter $\chi = 0.53$ and $\theta = 0.82$. "Weight shares" refers to the (time-averaged) weight shares in the social welfare function of the baseline for each income percentile. "Campaign contribution shares" are computed from Benabou (2000), Table 1, row 4 (Contribute Money) according to the formula: representation ratios × width of income percentile. We renormalized, because the computed contribution shares deviated slightly from unity.

The following Table 4 compares the business cycle statistics of endogenously determined

ratio of roughly 0.15 in the data. This means: $\theta = 0.77$ for $\chi = 0$, $\theta = 0.78$ for $\chi = 0.1$, $\theta = 0.79$ for $\chi = 0.2$, $\theta = 0.795$ for $\chi = 0.3$, $\theta = 0.805$ for $\chi = 0.4$, $\theta = 0.815$ for $\chi = 0.5$, $\theta = 0.82$ for $\chi = 0.53$, $\theta = 0.825$ for $\chi = 0.6$, $\theta = 0.835$ for $\chi = 0.7$, $\theta = 0.845$ for $\chi = 0.8$, $\theta = 0.855$ for $\chi = 0.9$ and $\theta = 0.865$ for $\chi = 1.0$. We also check, whether the decline of the contemporaneous correlation coefficient between output and government purchases is somehow produced by this recalibration. This is not the case.

[25]The average Gini coefficient of this model is 0.756 and the fraction of agents with negative wealth 10.1%. This is broadly in line with the data, see Krusell and Smith (1998). The coefficients for the KS rules and the $R2$ for the $\chi = 0.53$ case can be found in Tables 14 to 16 in Appendix C. The other coefficients and $R2$ are available from the authors upon request.

[26]When we use wealth percentiles the results are similar, given that wealth and income are highly correlated in our model.

government purchases from model simulations of our baseline wealth bias case with a case that like the baseline model quantitatively matches the U.S. wealth distribution, but has zero wealth bias in the social welfare function ($\chi = 0$). The third column includes the representative household case with no lags in government purchases for comparison. Other business cycle statistics can be found in Table 18 in Appendix D. It is worth noting that the dynamics of other aggregate variables are virtually identical across different values of χ.[27]

Table 4: BUSINESS CYCLE STATISTICS OF GOVERNMENT PURCHASES - BASELINE SIMULATION

Moment	Baseline ($\chi = 0.53$)	$\chi = 0$	Rep. Agent	Data
G				
St. dev.	0.54%	1.11%	1.08%	1.87%
Autocorrel. 1st-order	0.84	0.57	0.62	0.74
Autocorrel. 2nd-order	0.53	0.19	0.25	0.27
Correl. w. Y	0.50	0.98	0.96	0.47
Correl. w. Y-Lag.	0.74	0.60	0.66	0.58
Correl. w. C	0.78	0.98	0.98	0.49
C				
Autocorrel. 1st-order	0.66	0.66	0.69	0.62
Autocorrel. 2nd-order	0.30	0.30	0.34	0.09
Correl. w. Y	0.93	0.92	0.90	0.87

Notes: see notes to table 2. "Baseline" refers to the heterogeneous agent model with wealth bias parameter $\chi = 0.53$ and $\theta = 0.82$. $\chi = 0$ is a model without any wealth bias in the social welfare function, its corresponding θ is 0.77.

First, it can be seen that in the baseline case the fraction of endogenously explained volatility of government purchases is halved, from 58% to 29%. In the case with no political bias the level of amplification remains the same as in the representative agent case. Also, with respect to the other business cycle moments, the case with quantitatively realistic wealth heterogeneity but no wealth bias in the political mechanism displays strikingly similar dynamics of government purchases to the representative agent case: lower persistence than in the data and excess contemporaneous correlations with aggregate output and private consumption. This means that heterogeneity per se does not alter the dynamics of government purchases relative to the representative agent case. This in turn yields another case of irrelevance of wealth heterogeneity for aggregate dynamics - government purchases dynamics, to be precise -, extending the finding of Krusell and Smith (1998) to another class of models. In contrast, the baseline model with wealth heterogeneity and political wealth bias reduces the correlations of government purchases with aggregate output and private consumption considerably and brings them closer to the data. With 0.78 versus 0.49 in the data the baseline model still overshoots the contempora-

[27] The business cycle statistics for the other cases of χ are available upon request from the authors.

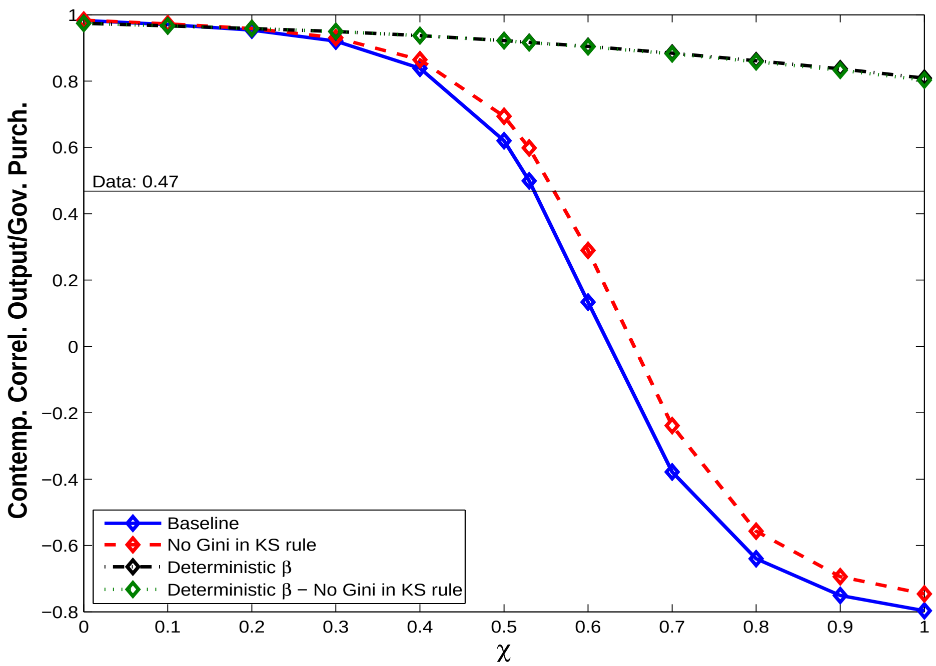
neous correlation with private consumption but the move is clearly in the right direction. Also, the baseline model overshoots with respect to the dynamic correlation with output relative to the data, but it does capture the relative strengths of the two correlation coefficients and, as in the data, places the peak correlation at a one-year output lag.[28] Finally, the baseline case also displays stronger propagation with respect to government purchases: both in an absolute sense, but also relative to private consumption, as is the case in the data. At least when measured in terms of the first-order autocorrelation, the baseline case overshoots the value in the data, but is still somewhat closer than the representative agent case or the case without political bias. However, the baseline model clearly provides too much propagation in terms of second-order autocorrelation. This finding is somewhat mitigated, however, when we take into account that according to Table 9 in Appendix A the non-defense component (GND) gives relatively low estimates for the autocorrelation coefficients compared to other government purchases aggregates. We will take this up in Section 4.4, when we calibrate to total government purchases, G, which displays higher first-order and second-order autocorrelation than GND. Altogether, we view the results in Table 4 as at least suggestive of wealth heterogeneity and wealth bias in societal decision making playing important roles in understanding not only long-run facts about government variables, but also about business cycle dynamics of government purchases. The fact that the range of values of χ that is preferred by at least some aspects of aggregate dynamics also lines closely up with the value that would be implied by indirect cross-sectional evidence on political inequality, lends additional credibility to this mechanism. Conversely, we show here that aggregate government purchases dynamics provide important restrictions on a difficult-to-measure structural parameter, which suggests that future empirical studies should take into account these dynamics.

Nevertheless, Table 4 also shows that there is a tension in our model between amplification and propagation/comovement with respect to government purchases and the role of heterogeneity and political bias. A large portion of government purchases fluctuations remains unexplained, and the fact that we have too much propagation probably indicates that we are missing an important additional shock with relatively low persistence. Pursuing this would be beyond the scope of this paper. In the following section, we show in more detail how heterogeneity and wealth bias interact to produce the result.

[28]At a level of $\chi = 0.6$ the correlation of government purchases with private consumption is 0.47 and the dynamic correlation with output 0.64, both very close to the data, while the contemporaneous correlation with output undershoots at 0.13. The point of this paper, however, is not a formal estimation of the parameters of the model as those that minimize the model distance from the second moments in the data, but to illustrate mechanisms that could bring the model closer to the data.

4.3 The Role of Heterogeneity

Figure 2: Correlation Between Y and G as a Function of Wealth Bias - The Role of Heterogeneity



Notes: see notes to figure 1. "No Gini in KS rule" refers to the equilibrium, when we simply leave out the Gini coefficient in the Krusell-Smith rules for capital and government purchases. "Deterministic β" refers to the equilibrium, when we make the discount factor deterministic and set it to its median value 0.96, but continue to use the Gini coefficient in the Krusell-Smith rules for capital and government purchases. "Deterministic β - No Gini in KS rule" refers to the equilibrium with deterministic β and no Gini coefficient in the Krusell-Smith rules.

Figure 2 repeats the same exercise as in Figure 1: we show how the contemporaneous correlation between GDP and government purchases in the model simulations varies with the wealth bias in the social welfare function. We also display this variation now in three variants of the baseline computation: first, we simply leave out the Gini coefficient in the Krusell-Smith rules for capital and government purchases ("No Gini in KS rule" - red, dashed line),[29] and recompute the equilibrium; secondly, we do not target a realistic Gini coefficient in the simulated wealth distribution and set the discount factor to a deterministic value of 0.96, but leave the higher moment in the Krusell-Smith rules (black, dashed-dotted line); thirdly, we combine both changes (green, dotted line).[30] Comparing the baseline computation with the Gini coefficient in the Krusell-Smith rules and the recomputed equilibrium without any higher moments (red

[29]See equations(6)-(8).

[30]The resulting Gini coefficient is 0.46 and the fraction of negative wealth holders is 2.8% across models, whether we use the Gini coefficient or not in the Krusell-Smith rules. The graph shows the cases, where in the three compu-

line) shows that our baseline model is a quantitatively realistic example where there is at least a small deviation from approximate aggregation in the sense of Krusell and Smith (1998). Using a measure of wealth inequality in the equilibrium law of motion changes actual equilibrium dynamics slightly for higher political bias parameters - the solid blue and the dashed red line deviate from each other for higher χ. When agents do not take into account the dynamics of wealth inequality in their forecasting rules, the desynchronisation effect that a highly unequal wealth distribution in concert with a wealth-biased political system brings about is slightly mitigated. The contemporaneous correlation between output and government purchases increases to from 0.50 to 0.60, when the Gini coefficient is left out; conversely, χ would have to be slightly increased to 0.57 to match the relevant correlation in the data. Switching to a counterfactual wealth distribution with small inequality nearly eliminates the effect of wealth bias on aggregate government purchases dynamics, whether we include higher moments in the forecasting rules or not. In fact, with low wealth inequality the aggregate dynamics of the economies are unaltered for any level of χ, when we include the Gini coefficient into the Krusell-Smith rules.[31] Finally, in the case of complete political equality, $\chi = 0$, heterogeneity is irrelevant for aggregate dynamics and the economy behaves essentially as in the representative agent case.

The joint effect of a highly unequal wealth distribution and a political aggregation mechanism that translates wealth inequality into political inequality can also be seen when looking at the persistence measures for government purchases.[32]

Table 5: PERSISTENCE OF GOVERNMENT PURCHASES

	Autocorrel. 1st-order		Autocorrel. 2nd-order	
Case	$\chi = 0$	$\chi = 0.53$	$\chi = 0$	$\chi = 0.53$
Baseline	0.57	0.84	0.19	0.53
No Gini in KS rule	0.57	0.83	0.19	0.51
Deterministic β	0.59	0.67	0.22	0.31
Deterministic β - No Gini in KS rule	0.59	0.67	0.22	0.31

Notes: see notes to table 2.

Table 5 displays the first- and second-order autocorrelation coefficients for the four specifications from Figure 2, for the case of no political inequality and the baseline political inequality. The baseline case exhibits high persistence and this has to do with the fact that government

tational variants we do not recalibrate θ to match the $\frac{G}{Y}$-ratio. Instead the θs are taken as in the baseline exercise, see footnote 24. Indeed leaving out the Gini coefficient from the baseline calibration also slightly changes steady state values for high values of $\chi \geq 0.7$. Also, fixing β at 0.96 changes steady state values slightly. When we recalibrate, the graphs look almost identical.

[31] The coefficients for the KS rules and the $R2$ for the "No Gini in KS rule" case can be found in Tables 14 to 16 in Appendix C. The other coefficients and $R2$ are available from the authors upon request.

[32] The other business cycle statistics for these cases are available upon request from the authors.

purchases dynamics now depend directly on a slow-moving and itself persistent object, the wealth distribution. The aforementioned tension between propagation and amplification appears again.[33] With a deterministic discount factor, economic inequality is too small to matter, with $\chi = 0$ economic inequality does not get translated into political inequality.

A re-write of the budget constraint illustrates why wealth – or more specifically income – inequality generates scope for a decoupling of government purchases dynamics from the aggregate economy. Heterogeneity generates potential political conflict, which is the stronger the larger wealth inequality is. As we have seen, this potential political conflict then requires translation into actual political inequality through the wealth bias in the social welfare function to break the mainly intertemporal considerations that determine government purchases in the representative agent model and thus to become virulent for aggregate government purchases dynamics. This can be seen through the changes from the $\chi = 0$ to the $\chi = 1$ case. Plugging the tax function $\tau(K,z,G) = \frac{G}{zK^{\alpha}L^{1-\alpha}}$ into the budget constraint, yields:

$$c + k' = (1-\delta)k + \big(1-\tau(K,z,G)\big)\big(w(K,z)\tilde{l}\epsilon + r(K,z)k\big).$$

Rearranging terms we get:

$$c + p(k,\epsilon;K,z)G + k' = (1-\delta)k + w(K,z)\tilde{l}\epsilon + r(K,z)k,$$

where

$$p(k,\epsilon;K,z) \equiv \frac{w(K,z)\tilde{l}\epsilon + r(K,z)k}{zK^{\alpha}L^{1-\alpha}}$$

can be viewed as the relative price of G for a household with characteristic (k,ϵ). Viewed in this way, it is as if each household faces an individual-specific relative price when choosing c and G. The heterogeneity of relative prices, produced through capital and labor income heterogeneity, then introduces different policy preferences and potential conflict in public policy making.

To understand the contribution of economic characteristics to relative price heterogeneity, we insert the factor price conditions, $w(K,z) = (1-\alpha)zK^{\alpha}L^{-\alpha}$ and $r(K,z) = \alpha zK^{\alpha-1}L^{1-\alpha}$, to get:

$$p(k,\epsilon;K,z) = \alpha\frac{k}{K} + (1-\alpha)\frac{\tilde{l}\epsilon}{L}.$$

This equation represents the relative price between c and G for individual (k,ϵ) as a weighted average of relative capital and relative labor efficiency, with weights given by their importance in the production function. There are two sources of economic heterogeneity on the relative price. First, wealth heterogeneity contributes to the heterogeneity of relative prices. A wealth-poor

[33] In the "Deterministic β"-cases the volatility of government purchases only declines from 1.06% to 0.85%, when χ is raised from 0 to 0.53.

household faces a lower relative price and vice versa. Second, heterogeneity of labor efficiency also leads to heterogeneity of prices. Notice that aggregate technology shocks do not affect the relative price. As a result, relative price movements over the business cycle can only come from changing inequality.

Notice that the induced heterogeneity of relative prices vanishes in the representative agent model, as $p\left(K, \int_0^1 \epsilon_i di; K, z\right) = 1$. As a result, relative price heterogeneity introduces a unique channel to influence government policies over the business cycles.

Two final numerical exercises demonstrate the role of time-varying relative prices and distributions of relative prices from the opposite angle. We do so directly in the computation of the baseline case by making a household the political dictator that has the median labor efficiency $\epsilon = 1$[34] and the average capital level of the economy as her individual capital level, and thus eliminate the effect of political disagreement over time. Instead of determining government purchases through a (wealth-weighted) social welfare function, government purchases are now determined by the preferences of such an average household. Of course, this dictator is not one specific person or even one constant economic type over the cycle, but rather always an average agent. This exercise allows us to further disentangle the effects of political conflict and political inequality from the effects of economic inequality – the wealth concentration in this economy is unaltered compared to the baseline case. The numbers in Table 6 show that time-varying disagreement is indeed needed to generate decoupling of government purchases dynamics from the aggregate economy. Column one refers to a case, where we use the equilibrium best-response value function from the baseline equilibrium and resimulate the economy once. Column two refers to the case, where we let the equilibrium converge and where, thus, the best-response and continuation value functions are consistent with the new dictator-equilibrium. As can be seen in Table 6 the "dictator for one-shot deviation"-case already exhibits the high comovement and low persistence of government purchases characteristic of the representative agent case and the heterogeneous agent case with no political inequality, which continue to hold once consistency of individual behavior and equilibrium dynamics in this dictator economy is attained.

[34]There is a small Jensen's inequality effect here in that median labor productivity is not average labor productivity, which simply means that the relative price is not exactly equal to unity as in the representative agent case. This is irrelevant as the relative price is still constant and what matters is a time-varying relative price.

Table 6: THE ROLE OF CONFLICT

Moment	Baseline	Dictator: One-shot Deviation	Dictator: Full Equilibrium
Correl. w. Y	0.50	0.97	0.97
Autocorrel. 1st-order	0.84	0.60	0.60
Autocorrel. 2nd-order	0.53	0.23	0.23

Notes: see notes to table 4. "Dictator: One-shot Deviation" refers to a case, where we use the equilibrium best-response value function from the baseline equilibrium and resimulate the economy once. "Dictator: Full Equilibrium" refers to the case, where we let the equilibrium converge to guarantee consistence between individual behavior and equilibrium dynamics.

4.4 Robustness

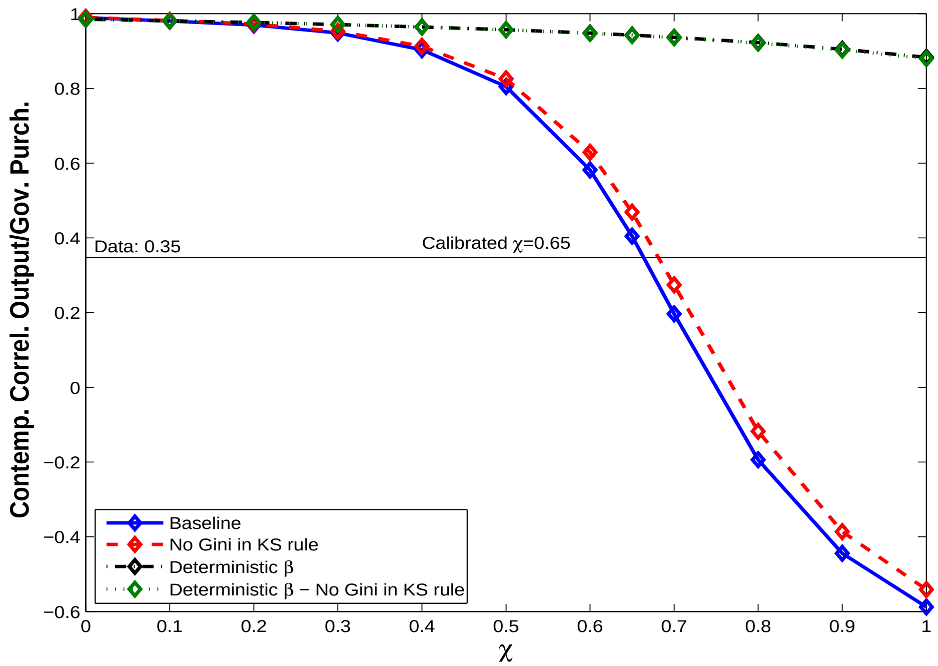
In this section we discuss robustness of our results with respect to one calibration choice and one modeling choice we have made in our baseline case. As has been discussed in Section 3.5, we use government non-defense purchases as a reasonable proxy for endogenous government purchases. It is the endogenous component of government purchases which this paper focusses on. In doing so, we follow a vast empirical literature that views only defense government purchases as a truly exogenous stochastic process and uses this assumption for the identification of the economic consequences of exogenous government spending shocks. Nevertheless, it is not obvious that all defense government spending is orthogonal to the state of the economy. This seems especially plausible for military spending in peace times. In fact, Table 9 in Appendix A suggests that if anything federal defense expenditures are somewhat more correlated with the cycle than federal non-defense expenditures. Therefore, we repeat our baseline exercise, but calibrate the love-for-government-purchases parameter, θ, to match the $\frac{G}{Y}$-ratio that is based on total government consumption and investment expenditures, G, including defense spending: 22.5%. Secondly, the baseline model featured a (wealth-weighted) social welfare function as the political aggregation mechanism, which we showed to be equivalent to a (wealth-weighted) probabilistic voting mechanism. In this section, we also study a case where we use (wealth-weighted) majority voting as the political constitution.[35]

Figure 3 shows the equivalent of Figure 2 in Section 4.3, when we use G as our data counterpart. It can again be seen that higher political bias leads to a decoupling of government purchases and the aggregate economy. For the total government purchases calibration the $\frac{G}{Y}$-ratio and the dynamic contemporaneous correlation between GDP and government purchases are approximately matched at $\theta = 0.72$ and $\chi = 0.65$.[36]

[35] We check numerically that the indirect preferences of the agents are indeed single-peaked in government purchases in our simulations.

[36] As before, we recalibrate θ to match the corresponding $\frac{G}{Y}$-ratio for each χ in the cases with stochastic β and a

Figure 3: Correlation Between Y and G as a Function of Wealth Bias - Calibration to Total Government Purchases



Notes: see notes to table 1.

Table 7 displays the business cycle statistics for the high $\frac{G}{Y}$-ratio calibration and compares them with a case with no political bias, a correspondingly calibrated representative agent case[37] and the baseline case with a lower $\frac{G}{Y}$-ratio. The other results on top of decoupling that we discussed in Section 4.2 can be found again: the model does poorly in terms of the volatility of government purchases, whereas in terms of endogenously generated persistence the heterogeneous agent model with wealth bias is now even closer to the data. The first-order autocorrelation coefficient in the data is almost exactly reached, and the overshooting in terms of second-order autocorrelation is not as severe as under the GND-calibration. In fact, even just based on this statistic, the data now slightly prefer the wealth bias model over the representative agent or the $\chi = 0$-model. In terms of the dynamic output correlation and the correlation with consumption the calibration with $\chi = 0.65$ still has not enough decoupling, but increas-

Gini coefficient in the Krusell-Smith rule. That means: $[\chi = 0, \theta = 0.665]$, $[\chi = 0.1, \theta = 0.675]$, $[\chi = 0.2, \theta = 0.68]$, $[\chi = 0.3, \theta = 0.69]$, $[\chi = 0.4, \theta = 0.70]$, $[\chi = 0.5, \theta = 0.705]$, $[\chi = 0.6, \theta = 0.715]$,$[\chi = 0.7, \theta = 0.725]$,$[\chi = 0.8, \theta = 0.735]$,$[\chi = 0.9, \theta = 0.745]$,$[\chi = 1.0, \theta = 0.76]$. For the three computational variants we then use the same θ. Notice that on average the θ's are lower in the high $\frac{G}{Y}$-ratio case: the relative importance of private consumption in the utility function has to be decreased in order to increase the $\frac{G}{Y}$-ratio. The coefficients for the KS rules and the $R2$ for the $\chi = 0.65$-case can be found in Tables 14 to 16 in Appendix C. The other coefficients and $R2$ are available from the authors upon request.

[37] $\theta = 0.675$ is needed to reach $\frac{G}{Y} = 0.225$.

Table 7: BUSINESS CYCLE STATISTICS OF GOVERNMENT PURCHASES - CALIBRATION TO TOTAL GOVERNMENT PURCHASES

Moment	G-Calib. ($\chi = 0.65$)	G-Calib. ($\chi = 0$)	Rep. Agent	Data	Baseline
G					
St. dev.	0.59%	1.37%	1.24%	2.81%	0.54%
Autocorrel. 1st-order	0.85	0.55	0.59	0.79	0.84
Autocorrel. 2nd-order	0.53	0.17	0.21	0.38	0.53
Correl. w. Y	0.40	0.99	0.98	0.35	0.50
Correl. w. Y-Lag.	0.75	0.58	0.62	0.51	0.74
Correl. w. C	0.68	0.97	0.97	0.35	0.78
C					
Autocorrel. 1st-order	0.65	0.65	0.68	0.62	0.66
Autocorrel. 2nd-order	0.29	0.29	0.33	0.09	0.30
Correl. w. Y	0.94	0.93	0.91	0.87	0.93

Notes: see notes to table 2. "G-Calib. ($\chi = 0.65$)" refers to a calibration, where we base the $\frac{G}{Y}$-ratio on total government purchases, as opposed to non-defense expenditures. "G-Calib. ($\chi = 0$)" refers to the same calibration but without any wealth bias in the political mechanism. The "Rep. Agent" case was also recalibrated to match the new $\frac{G}{Y}$-ratio. "Baseline" refers to the model with wealth bias parameter $\chi = 0.53$ and $\theta = 0.82$ that we calibrated to non-defense government purchases.

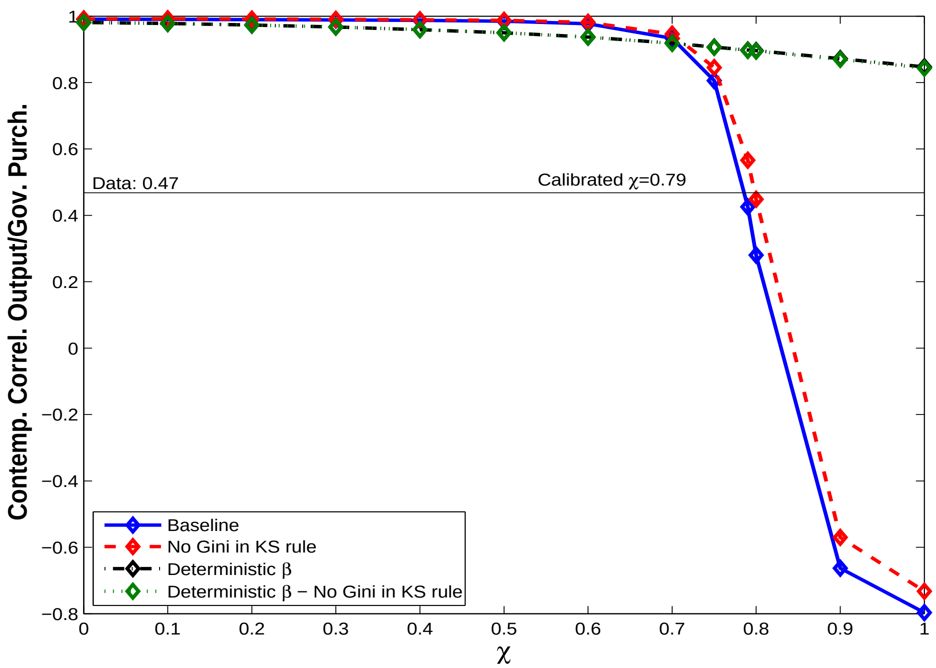
ing χ to somewhere between 0.7 and 0.8 could also approximate these statistics better, while making the contemporaneous output correlation close to zero. Again, this paper uses only one aggregate shock and one parameter - political bias - and therefore cannot match all these correlations perfectly. Table 19 in Appendix D displays the other business cycle statistics for this case.

Figure 4 repeats our exercises for the case of majority voting, where again higher political bias yields decoupling of government purchases and the aggregate economy. Interestingly, for the majority voting case the slope of the decline of the contemporaneous correlation coefficient between output and government purchases[38] in χ is much flatter initially and much steeper for higher values of χ, when compared to the probabilistic voting case. The $\frac{G}{Y}$-ratio and the dynamic contemporaneous correlation between GDP and government purchases are approximately matched at $\theta = 0.825$ and $\chi = 0.79$.[39]

[38] We find the same for the dynamic output correlation and the contemporaneous one with private consumption.

[39] We recalibrate θ to match the corresponding $\frac{G}{Y}$-ratio for each χ: [$\chi = 0, \theta = 0.76$], [$\chi = 0.1, \theta = 0.765$], [$\chi = 0.2, \theta = 0.77$], [$\chi = 0.3, \theta = 0.775$], [$\chi = 0.4, \theta = 0.78$], [$\chi = 0.5, \theta = 0.785$], [$\chi = 0.6, \theta = 0.795$],[$\chi = 0.7, \theta = 0.81$],[$\chi = 0.75, \theta = 0.82$],[$\chi = 0.8, \theta = 0.825$],[$\chi = 0.9, \theta = 0.84$],[$\chi = 1.0, \theta = 0.85$]. For the three computational variants we then use the same θ. The coefficients for the KS rules and the $R2$ for the $\chi = 0.79$-case can be found in Tables 14 to 16 in Appendix C. The other coefficients and $R2$ are available from the authors upon request.

Figure 4: Correlation Between Y and G as a Function of Wealth Bias - Wealth-weighted Majority Voting



Notes: see notes to table 1.

Table 8: BUSINESS CYCLE STATISTICS OF GOVERNMENT PURCHASES - WEALTH-WEIGHTED MAJORITY VOTING

Moment	Voting ($\chi = 0.79$)	Voting ($\chi = 0$)	Baseline	Rep. Agent	Data
G					
St. dev.	0.39%	1.27%	0.54%	1.08%	1.87%
Autocorrel. 1st-order	0.67	0.54	0.84	0.62	0.74
Autocorrel. 2nd-order	0.35	0.16	0.53	0.25	0.27
Correl. w. Y	0.43	0.99	0.50	0.96	0.47
Correl. w. Y-Lag.	0.65	0.56	0.74	0.66	0.58
Correl. w. C	0.66	0.95	0.78	0.98	0.49
C					
Autocorrel. 1st-order	0.66	0.66	0.66	0.69	0.62
Autocorrel. 2nd-order	0.30	0.30	0.30	0.34	0.09
Correl. w. Y	0.93	0.92	0.93	0.90	0.87

Notes: see notes to table 2. "Voting ($\chi = 0.79$)" refers to a simulation, where we use wealth-weighted majority voting as opposed to a wealth-weighted social welfare function as the political mechanism. "Voting ($\chi = 0$)" is the same but without any wealth bias in the political mechanism. "Baseline" refers to the heterogeneous agent model with wealth bias parameter $\chi = 0.53$ and $\theta = 0.82$. All models are calibrated to non-defense government purchases.

Table 8 displays the business cycle statistics for the majority-voting case and compares them with a case with no political bias, the representative agent case[40] and the baseline case with a social welfare function/probabilistic voting. The majority voting case brings an improvement in terms of lower persistence compared to the probabilistic voting case, which is closer to the data. However, the fraction of endogenously explained government purchases volatility declines even further. Just as with the baseline calibration, the message from this underexplanation of government purchases volatility is that there probably is a truly exogenous component to the stochastic process of government purchases from which this paper deliberately abstracts. Table 20 in Appendix D displays the other business cycle statistics for this case.

This concludes the results section. Decoupling of government purchases dynamics from the aggregate economy is a robust phenomenon in heterogeneous agent environments with quantitatively realistic wealth inequality and wealth bias in the political decision mechanism that does not depend on the specifics of the political system, nor the average importance of the government sector in the economy.

5 Final Remarks

To the best of our knowledge, this paper is the first to try to explain the business cycle dynamics of government purchases in a quantitative model. In doing so, it fills an important gap in the literature, because our paper does for one relatively large and fairly volatile component of domestic aggregate demand what macroeconomics since the quantitative revolution has done for private consumption and investment. It set up and computed a neoclassical growth model where agents face uninsurable idiosyncratic labor income risk and where the equilibrium wealth distribution featured a realistic concentration. In this model, households value government purchases which are financed solely by income taxes. The government cannot commit to future streams of government purchases and thus a game is played between successive government. We study the Markov perfect equilibria of such an economy. We also introduce wealth bias into the political aggregation process. By providing an estimate of wealth bias in a fully dynamic structural model, we make inroads into a structural approach of identifying latent characteristics of the political process. When exposed to standard aggregate productivity shocks, we show that such model can explain three important features of government purchases in the data: government purchases are mildly procyclical, their dynamic correlation with one-year lagged output is higher than the contemporaneous correlation and they are the most persistent component of aggregate demand. We also show that a corresponding representative agent model,

[40]Notice that with a representative agent there is obviously no difference between probabilistic and majority voting.

models with insufficient wealth concentration and models with no wealth bias cannot explain these features of the data. However, we also show that there is a tension between amplification and propagation/comovement with respect to government purchases as it pertains to economic and political inequality: models without either of these features dominate those with them in terms of the fraction of volatility of government purchases that can be endogenously explained.

In keeping the model tractable we abstract from an endogenous labor supply decision and government debt. Both mean substantial computational complications, which we plan to tackle in future research. In a similar vein, it seems important to study the dynamics of more disaggregated categories of government purchases and total government spending, including transfers in our model set up. This also holds true for the study of other political institutions such as legislative bargaining in the spirit of Battaglini and Coate (2008a, 2008b).

Finally, the fact that our model can only explain roughly one third of the volatility of government purchases and also makes them somewhat too persistent relative to the data suggests that a second, only mildly persistent shock – perhaps a shock to the taste for government purchases – is operating. We again leave this for future research.

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A Data - Appendix

Table 9: BUSINESS CYCLE FACTS FOR DISAGGREGATE GOVERNMENT PURCHASES

Moment	St. dev.	Autocorrel. 1st-order	Autocorrel. 2nd-order	Correl. w. Y	Correl. w. Y-Lag.	Frac. of G
G	2.81%	0.79	0.38	0.35	0.51	100%
GC	2.40%	0.78	0.39	0.26	0.43	84.6%
GI	5.83%	0.75	0.30	0.47	0.59	15.6%
GND	1.87%	0.74	0.27	0.47	0.58	68.8%
$GNDC$	1.52%	0.70	0.32	0.19	0.34	56.5%
$GNDI$	5.00%	0.74	0.24	0.60	0.66	12.0%
GF	5.22%	0.82	0.48	0.15	0.27	42.7%
GFC	4.93%	0.82	0.49	0.12	0.25	38.3%
GFI	10.09%	0.73	0.32	0.18	0.28	5.0%
GFD	6.99%	0.83	0.49	0.13	0.26	31.2%
$GFDC$	6.50%	0.85	0.52	0.13	0.24	28.0%
$GFDI$	13.69%	0.71	0.26	0.08	0.27	3.6%
$GFND$	4.36%	0.63	0.18	0.04	-0.01	11.7%
$GFNDC$	3.70%	0.47	0.08	-0.09	-0.04	10.3%
$GFNDI$	9.95%	0.71	0.27	0.27	0.03	1.5%
GSL	2.06%	0.76	0.35	0.49	0.65	57.1%
$GSLC$	1.80%	0.77	0.42	0.24	0.39	46.3%
$GSLI$	5.21%	0.72	0.21	0.62	0.73	10.7%
$G-Empl.$	1.65%	0.75	0.29	0.26	0.62	-

Notes: G denotes government consumption and gross investment expenditures, a C in an acronym means consumption, an I investment. D stands for defense spending, ND for non-defense. F means federal government, SL the aggregate of state and local governments. $G-Empl.$ stands for government employment. All variables are annual, they range from 1960-2006. They are deflated by their corresponding deflators, and for columns 2-6 logged and filtered with a Hodrick-Prescott filter with smoothing parameter 100. The last column shows the fraction of each component of government purchases in total G. Sources: Tables 3.9.4 and 3.9.5 from the NIPA accounts.

B Calibration - Appendix

Table 10: Common Parameters

Parameter	δ	α	$\underline{k}$
Value	0.1	0.36	0.01

Table 11: Markov Chain: Aggregate Productivity

State	z_1	z_2	z_3	z_4	z_5
Value	0.9182	0.9582	1	1.0436	1.0891
z_1	0.6306	0.3676	0.0018	0.0000	0.0000
z_2	0.0382	0.7538	0.2077	0.0003	0.0000
z_3	0.0001	0.0980	0.8039	0.0980	0.0001
z_4	0.0000	0.0003	0.2077	0.7538	0.0382
z_5	0.0000	0.0000	0.0018	0.3676	0.6306

Notes: This Markov chain is based on an autocorrelation coefficient of 0.8145 and conditional standard deviation of 0.0165. It was generated with Tauchen's (see Tauchen, 1986) discretization method and a width-parameter of 3.

Table 12: MARKOV CHAIN: IDIOSYNCRATIC LABOR PRODUCTIVITY

State	ϵ_1	ϵ_2	ϵ_3	ϵ_4	ϵ_5	ϵ_6	ϵ_7	ϵ_8	ϵ_9
Value	0.4420	0.5421	0.6648	0.8154	1	1.2264	1.5041	1.8447	2.2623
ϵ_1	0.2854	0.4292	0.2409	0.0422	0.0023	0.0000	0.0000	0.0000	0.0000
ϵ_2	0.0782	0.3102	0.4140	0.1739	0.0227	0.0009	0.0000	0.0000	0.0000
ϵ_3	0.0117	0.1167	0.3716	0.3716	0.1167	0.0113	0.0003	0.0000	0.0000
ϵ_4	0.0009	0.0227	0.1739	0.4140	0.3102	0.0728	0.0053	0.0001	0.0000
ϵ_5	0.0000	0.0023	0.0422	0.2409	0.4292	0.2409	0.0422	0.0023	0.0000
ϵ_6	0.0000	0.0001	0.0053	0.0728	0.3102	0.4140	0.1739	0.0227	0.0009
ϵ_7	0.0000	0.0000	0.0003	0.0113	0.1167	0.3716	0.3716	0.1167	0.0117
ϵ_8	0.0000	0.0000	0.0000	0.0009	0.0227	0.1739	0.4140	0.3102	0.0782
ϵ_9	0.0000	0.0000	0.0000	0.0000	0.0023	0.0422	0.2409	0.4292	0.2854

Notes: This Markov chain is based on an autocorrelation coefficient of 0.75 and conditional standard deviation of 0.18. It was generated with Tauchen's (see Tauchen, 1986) discretization method and a width-parameter of 3.

Table 13: MARKOV CHAIN: DISCOUNT FACTOR

State	β_1	β_2	β_3
Value	0.94	0.96	0.98
β_1	0.9800	0.0200	0
β_2	0.0025	0.9950	0.0025
β_3	0	0.0200	0.9800

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Table 14: KRUSELL-SMITH RULES FOR AVERAGE CAPITAL - EQUATION(6)

z	a_0	a_1	a_2	a_3	a_4	$R2$
			Representative Agent Case - No Lags			
z_1	-0.4495	0.9102	-	-0.2698	-0.0397	0.9994
z_2	-0.4188	0.9061	-	-0.2589	-0.0381	0.9994
z_3	-0.3916	0.9017	-	-0.2503	-0.0368	0.9994
z_4	-0.3595	0.8981	-	-0.2389	-0.0351	0.9995
z_5	-0.3288	0.8941	-	-0.2289	-0.0337	0.9995
			Baseline Case, $\theta = 0.82$, $\chi = 0.53$			
z_1	-0.3310	0.9147	0.0399	-0.2110	-0.0305	0.9997
z_2	-0.3126	0.9083	0.0269	-0.2058	-0.0298	0.9996
z_3	-0.2942	0.9027	0.0201	-0.2017	-0.0292	0.9996
z_4	-0.2702	0.8993	0.0198	-0.1950	-0.0283	0.9996
z_5	-0.2429	0.9042	0.0403	-0.1891	-0.0275	0.9997
			Baseline Case, $\theta = 0.82$, $\chi = 0.53$, No Gini			
z_1	-0.3406	0.9017	-	-0.2122	-0.0307	0.9996
z_2	-0.3196	0.9000	-	-0.2070	-0.0300	0.9996
z_3	-0.2995	0.8957	-	-0.2028	-0.0294	0.9996
z_4	-0.2752	0.8918	-	-0.1962	-0.0285	0.9996
z_5	-0.2512	0.8878	-	-0.1901	-0.0277	0.9996
			G-calibration, $\theta = 0.72$, $\chi = 0.65$			
z_1	-0.3810	0.9167	0.0369	-0.2509	-0.0366	0.9996
z_2	-0.3578	0.9113	0.0286	-0.2434	-0.0356	0.9995
z_3	-0.3358	0.9056	0.0233	-0.2373	-0.0347	0.9995
z_4	-0.3062	0.9019	0.0236	-0.2273	-0.0333	0.9995
z_5	-0.2747	0.9032	0.0354	-0.2182	-0.0319	0.9996
			Majority Voting Case, $\theta = 0.825$, $\chi = 0.79$			
z_1	-0.3273	0.9169	0.0534	-0.2112	-0.0305	0.9996
z_2	-0.3097	0.9087	0.0357	-0.2057	-0.0298	0.9996
z_3	-0.2920	0.9019	0.0252	-0.2014	-0.0292	0.9996
z_4	-0.2681	0.8977	0.0224	-0.1944	-0.0282	0.9996
z_5	-0.2399	0.9028	0.0446	-0.1880	-0.0273	0.9997

Notes: z denotes aggregate productivity, which can achieve five discrete states: z_1 to z_5, Table 11 in Appendix B. The KS equation for average capital is given by: $\log K' = a_0(z) + a_1(z)\log K + a_2(z)\log Gini(k) + a_3(z)\log G + a_4(z)\left(\log G\right)^2$.

Table 15: KRUSELL-SMITH RULES FOR $Gini(k)$ - EQUATION(7)

z	$\widetilde{a}_0$	$\widetilde{a}_1$	$\widetilde{a}_2$	$\widetilde{a}_3$	$\widetilde{a}_4$	$R2$
Baseline Case, $\theta = 0.82$, $\chi = 0.53$						
z_1	0.1340	0.0252	0.9741	0.0851	0.0118	0.9996
z_2	0.1303	0.0213	0.9682	0.0860	0.0121	0.9995
z_3	0.1291	0.0245	0.9792	0.0867	0.0122	0.9995
z_4	0.1288	0.0323	1.0038	0.0862	0.0122	0.9995
z_5	0.1219	0.0303	0.9973	0.0861	0.0123	0.9995
G-calibration, $\theta = 0.72$, $\chi = 0.65$						
z_1	0.1582	0.0213	0.9755	0.1047	0.0147	0.9997
z_2	0.1536	0.0179	0.9712	0.1059	0.0150	0.9995
z_3	0.1508	0.0201	0.9783	0.1063	0.0152	0.9995
z_4	0.1477	0.0267	0.9968	0.1047	0.0151	0.9995
z_5	0.1409	0.0313	1.0056	0.1027	0.0148	0.9995
Majority Voting Case, $\theta = 0.825$, $\chi = 0.79$						
z_1	0.1312	0.0235	0.9639	0.0851	0.0119	0.9996
z_2	0.1279	0.0211	0.9615	0.0859	0.0121	0.9994
z_3	0.1272	0.0250	0.9751	0.0864	0.0122	0.9995
z_4	0.1276	0.0343	1.0043	0.0857	0.0122	0.9995
z_5	0.1200	0.0312	0.9951	0.0853	0.0122	0.9994

Notes: z denotes aggregate productivity, which can achieve five discrete states: z_1 to z_5, Table 11 in Appendix B. The KS equation for the natural logarithm of the Gini coefficient of capital is given by: $\log Gini(k') = \widetilde{a}_0(z) + \widetilde{a}_1(z)\log K + \widetilde{a}_2(z)\log Gini(k) + \widetilde{a}_3(z)\log G + \widetilde{a}_4(z)\left(\log G\right)^2$.

The KS rules and the corresponding $R2$ for all other cases discussed in this paper are available upon request from the authors.

Table 16: KRUSELL-SMITH RULES FOR GOVERNMENT PURCHASES - EQUATION(8)

z	b_0	b_1	b_2	$R2$
Representative Agent Case - No Lags				
z_1	-2.6424	0.4910	-	1.0000
z_2	-2.6205	0.4901	-	1.0000
z_3	-2.5985	0.4867	-	1.0000
z_4	-2.5751	0.4878	-	1.0000
z_5	-2.5527	0.4904	-	1.0000
Baseline Case, $\theta = 0.82$, $\chi = 0.53$				
z_1	-2.5950	0.6279	0.2498	0.9941
z_2	-2.5793	0.6495	0.3086	0.9971
z_3	-2.5873	0.6406	0.2490	0.9979
z_4	-2.6097	0.6143	0.1381	0.9988
z_5	-2.6203	0.5710	0.0454	0.9993
Baseline Case, $\theta = 0.82$, $\chi = 0.53$, No Gini				
z_1	-2.6227	0.5300	-	0.9858
z_2	-2.6186	0.5390	-	0.9925
z_3	-2.6116	0.5396	-	0.9942
z_4	-2.6085	0.5464	-	0.9971
z_5	-2.5982	0.5342	-	0.9988
G-calibration, $\theta = 0.72$, $\chi = 0.65$				
z_1	-2.1162	0.6137	0.3288	0.9982
z_2	-2.1142	0.6410	0.3349	0.9991
z_3	-2.1197	0.6536	0.2986	0.9992
z_4	-2.1372	0.6546	0.2313	0.9995
z_5	-2.1631	0.6030	0.1069	0.9997
Majority Voting Case, $\theta = 0.825$, $\chi = 0.79$				
z_1	-2.3049	0.7203	1.3271	0.8686
z_2	-2.3758	0.6143	0.9844	0.9207
z_3	-2.4743	0.4945	0.5137	0.9445
z_4	-2.5521	0.4035	0.1569	0.9602
z_5	-2.5625	0.3564	0.0624	0.9707

Notes: z denotes aggregate productivity, which can achieve five discrete states: z_1 to z_5, Table 11 in Appendix B. The KS equation for government purchases is given by: $\log G = b_0(z) + b_1(z)\log K + b_2(z)\log Gini(k)$.

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Table 17: BUSINESS CYCLE STATISTICS - REPRESENTATIVE AGENT SIMULATION

Moment	No Decision Lag	Decision Lag	Data
Y			
St. dev.	1.88%	1.89%	1.90%
Autocorrel. 1st-order	0.51	0.52	0.54
Autocorrel. 2nd-order	0.12	0.12	-0.02
C			
St. dev.	0.98%	1.00%	1.67%
Autocorrel. 1st-order	0.69	0.68	0.62
Autocorrel. 2nd-order	0.34	0.32	0.09
Correl. w. Y	0.90	0.92	0.87
Correl. w. Y-Lag.	0.73	0.71	0.41
I			
St. dev.	5.66%	6.08%	7.84%
Autocorrel. 1st-order	0.45	0.40	0.42
Autocorrel. 2nd-order	0.04	0.02	-0.16
Correl. w. Y	0.96	0.95	0.84
Correl. w. Y-Lag.	0.33	0.28	0.21
Correl. w. C	0.75	0.75	0.69

Notes: Y denotes GDP, C private consumption expenditures and I private gross fixed investment. All variables are logged and filtered with a Hodrick-Prescott filter with smoothing parameter 100. The simulation numbers come from a simulation of 1500 periods, where the first 500 periods were discarded. "No Decision Lag" refers to a simulation, where the political process decides about current government purchases. "Decision Lag" refers to a simulation, where the political process decides about government purchases one year ahead.

Table 18: BUSINESS CYCLE STATISTICS - BASELINE SIMULATION

Moment	Baseline ($\chi = 0.53$)	$\chi = 0$	Rep. Agent	Data
Y				
St. dev.	1.88%	1.87%	1.88%	1.90%
Autocorrel. 1st-order	0.51	0.51	0.51	0.54
Autocorrel. 2nd-order	0.12	0.11	0.12	-0.02
C				
St. dev.	1.09%	1.02%	0.98%	1.67%
Autocorrel. 1st-order	0.66	0.66	0.69	0.62
Autocorrel. 2nd-order	0.30	0.30	0.34	0.09
Correl. w. Y	0.93	0.92	0.90	0.87
Correl. w. Y-Lag.	0.70	0.69	0.73	0.41
I				
St. dev.	5.46%	5.07%	5.66%	7.84%
Autocorrel. 1st-order	0.45	0.45	0.45	0.42
Autocorrel. 2nd-order	0.05	0.04	0.04	-0.16
Correl. w. Y	0.97	0.97	0.96	0.84
Correl. w. Y-Lag.	0.34	0.35	0.33	0.21
Correl. w. C	0.81	0.81	0.75	0.69

Notes: see notes to table 17. "Baseline" refers to the heterogeneous agent model with wealth bias parameter χ = 0.53 and θ = 0.82. χ = 0 is a model without any wealth bias in the social welfare function, its corresponding θ is 0.77.

Table 19: BUSINESS CYCLE STATISTICS - CALIBRATION TO TOTAL GOVERNMENT PURCHASES

Moment	G-Calib. ($\chi = 0.65$)	G-Calib. ($\chi = 0$)	Rep. Agent	Data	Baseline
Y					
St. dev.	1.88%	1.87%	1.88%	1.90%	1.88%
Autocorrel. 1st-order	0.52	0.51	0.51	0.54	0.51
Autocorrel. 2nd-order	0.13	0.11	0.12	-0.02	0.12
C					
St. dev.	1.15%	1.01%	0.97%	1.67%	1.09%
Autocorrel. 1st-order	0.65	0.65	0.68	0.62	0.66
Autocorrel. 2nd-order	0.29	0.29	0.33	0.09	0.30
Correl. w. Y	0.94	0.93	0.91	0.87	0.93
Correl. w. Y-Lag.	0.69	0.69	0.72	0.41	0.70
I					
St. dev.	5.93%	5.13%	5.78%	7.84%	5.46%
Autocorrel. 1st-order	0.45	0.45	0.45	0.42	0.45
Autocorrel. 2nd-order	0.04	0.04	0.04	-0.16	0.05
Correl. w. Y	0.96	0.97	0.97	0.84	0.97
Correl. w. Y-Lag.	0.33	0.35	0.34	0.21	0.34
Correl. w. C	0.81	0.82	0.77	0.69	0.81

Notes: see notes to table 17. "G-Calib. ($\chi = 0.65$)" refers to a calibration, where we base the $\frac{G}{Y}$-ratio on total government purchases, as opposed to non-defense expenditures. "G-Calib. ($\chi = 0$)" refers to the same calibration but without any wealth bias in the political mechanism. The "Rep. Agent" case was also recalibrated to match the new $\frac{G}{Y}$-ratio. "Baseline" refers to the model with wealth bias parameter $\chi = 0.53$ and $\theta = 0.82$ that we calibrated to non-defense government purchases.

Table 20: Business Cycle Statistics - Wealth-weighted Majority Voting

Moment	Voting ($\chi = 0.79$)	Voting ($\chi = 0$)	Baseline	Rep. Agent	Data
Y					
St. dev.	1.87%	1.87%	1.88%	1.88%	1.90%
Autocorrel. 1st-order	0.51	0.50	0.51	0.51	0.54
Autocorrel. 2nd-order	0.12	0.11	0.12	0.12	-0.02
C					
St. dev.	1.11%	1.01%	1.09%	0.98%	1.67%
Autocorrel. 1st-order	0.66	0.66	0.66	0.69	0.62
Autocorrel. 2nd-order	0.30	0.30	0.30	0.34	0.09
Correl. w. Y	0.93	0.92	0.93	0.90	0.87
Correl. w. Y-Lag.	0.69	0.69	0.70	0.73	0.41
I					
St. dev.	5.44%	4.99%	5.46%	5.66%	7.84%
Autocorrel. 1st-order	0.45	0.45	0.45	0.45	0.42
Autocorrel. 2nd-order	0.05	0.04	0.05	0.04	-0.16
Correl. w. Y	0.97 0.97		0.97	0.96	0.84
Correl. w. Y-Lag.	0.35	0.35	0.34	0.33	0.21
Correl. w. C	0.81	0.81	0.81	0.75	0.69

Notes: see notes to table 17. "Voting ($\chi = 0.79$)" refers to a simulation, where we use wealth-weighted majority voting as opposed to a wealth-weighted social welfare function as the political mechanism. "Voting ($\chi = 0.72$)" is the same but without any wealth bias in the political mechanism. "Baseline" refers to the heterogeneous agent model with wealth bias parameter $\chi = 0.53$ and $\theta = 0.82$. All models are calibrated to non-defense government purchases.