Public Consumption Over the Business Cycle

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Abstract

What fraction of the business cycle fluctuations of government spending is accounted for by endogenous reactions to macroeconomic conditions? We answer this question in the framework of a neoclassical representative household model where the provision of a public consumption good is decided upon endogenously and in a time-consistent way. A simple frictionless version of such a model with aggregate productivity as the sole driving force can explain almost all the volatility of U.S. public consumption. However, this model fails to match other important features of the business cycle dynamics of public consumption. It is not persistent enough and too synchronized with the cycle. We add implementation lags and costs in the budgeting process as frictions plus taste shocks for public consumption relative to private consumption, and achieve a substantially better match to the data. All these ingredients are essential to improve the fit. In our preferred calibration then 40 percent of the variance of public consumption is driven by aggregate productivity shocks.

JEL Codes: E30, E32, E60, E62, H30.

Keywords: public consumption, aggregate productivity shocks, business cycles, implementation lags, adjustment costs, taste shocks, time-consistent public policy.

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1 Introduction

Public consumption has interesting business cycle features, which we carefully document in this paper. It is about as volatile as private consumption, roughly as persistent as aggregate output and, unlike any other component of aggregate demand, contemporaneously acyclical, but (mildly) procyclical with one- and two-year lags. Comparing peak correlations, public (or government) consumption is the least procyclical component of aggregate demand.

Standard business cycle analysis typically treats government purchases 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), Chari et al. (2007) or Leeper et al. (2010), for instance); in the vast empirical literature on the sign and magnitude of the government spending multiplier as a source of an exogenous shock to be identified (see Shapiro and Ramey (1998), Blanchard and Perotti (2002), Mountford and Uhlig (2009) or Ramey (2010), 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 that needs to be financed by either taxes or debt.

In this paper we reverse the perspective and ask: once we allow for a mechanism of endogenous public good provision, what fraction of the business cycle fluctuations of government spending is accounted for by endogenous reactions to macroeconomic conditions? And how much is generated through shocks in the political system? To answer this question we draw on previous work by Klein, Krusell and Rios-Rull (2008) (KKR henceforth), which features a neo-classical representative household model with time-consistent public policy. We discipline the exercise by requiring that the model match the business cycle features of public consumption described above. The model has a government that cannot commit ex ante to a path of public consumption, but takes into account future public consumption streams and how they depend on current decisions. The solution concept for the game between successive governments is the Markov-perfect equilibrium.\(^1\) Government consumption is financed by linear income taxes. We abstract from government debt and transfers.

As a first step, we add conventional aggregate productivity shocks as the sole aggregate driving force to the KKR framework, thus making it as close as possible to a standard real business cycle model.\(^2\) Our first result is that such a model can explain almost all the volatility of govern-

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\(^1\)This framework is consistent with the positive nature of our inquiry. In the words of Kocherlakota (2010): “These literatures [on time-consistency and dynamic political economy] examine the properties of equilibrium outcomes of particular dynamic games. Hence, they are trying to model actual behavior of governments.” (emphasis in the original).

\(^2\)Most of the related literature on endogenous public policy in a dynamic environment so far has focussed on long-run steady state questions: in addition to KKR, see Krusell et al. (1997), Krusell and Rios-Rull (1999), Hassler
ment consumption in the data, but falls short in terms of its persistence and makes government consumption almost perfectly and contemporaneously correlated with the cycle.

Motivated by the dynamic correlation pattern of government consumption in the data, we next add an implementation lag: today’s government can only decide about its consumption tomorrow and tomorrow’s government is bound by this decision. Implementation lags are a realistic feature of the budgeting process given the numerous bureaucracies involved with government expenditures. This will help us push the peak correlation of public consumption and output away from contemporaneous, but still leaves us with far too high a dynamic correlation.

We then include a taste shock for public consumption (relative to private consumption) in the flow utility of the representative household, which leads to a decoupling of economic aggregates and government consumption. However, this second shock makes government consumption too volatile and reduces persistence further compared to the data.

We remedy this, finally, by introducing implementation costs (in addition to the implementation lags). We assume that it is costly for governments to deviate too much from previous budgets. One interpretation for these somewhat reduced-form adjustment costs could be budget planning costs. Implementation lags and costs are modeled similarly to, respectively, time-to-build and smooth, convex adjustment costs for capital in standard macroeconomic models.

Our second result is that within the class of models we are studying only the model with two aggregate shocks and two implementation frictions (in addition to the “no commitment” friction) can produce a reasonable fit to all three dimensions of the business cycle dynamics of government purchases: volatility, persistence and comovement. Our final result is the answer to our original research question: in this model 40 percent of the fluctuations of public consumption are explained by endogenous reactions to macroeconomic conditions.

The reminder of the paper is organized as follows: the next section presents the business cycle facts for our baseline measure of government consumption, state and local consumption. Section 3 discusses the model, its calibration and computation. Section 4 presents the results and explains in detail how each of the model features contributes to the fit to the observed dynamics of public consumption. A final section concludes. Details are relegated to various appendices.

et al. (2003), Hassler et al. (2005), Song et al. (2007), Corbae et al. (2009), Azzimonti (2011), Bai and Lagunoff (2011). Models with aggregate shocks are featured in Azzimonti et al. (2008), Battaglini and Coate (2008), Barseghyan et al. (2010), Debortoli and Nunes (2010), Bachmann and Bai (2011).
2 Facts

Table 1 shows the business cycle moments for state and local government consumption (‘GSLC’), our main government purchases aggregate, as well as other cuts of total government purchases.

1. GSLC is at least as volatile as private consumption and roughly half as volatile as aggregate output (1.34%).

2. GSLC is fairly persistent, at least as persistent as output (0.292).

3. GSLC is contemporaneously acyclical.

4. GSLC is dynamically procyclical.

Table 1: Business Cycle Facts of Government Purchases

| Moment            | GSLC | GNDC | GND | GC | G | CNDS |
|-------------------|------|------|-----|----|---|------|
| Standard Dev.     | 0.783| 0.777| 0.943| 1.173| 1.362| 0.705|
| 1st-order Autocorr. | 0.296| 0.218| 0.412| 0.461| 0.534| 0.362|
| Correl(·, Y)      | 0.003| -0.013| 0.235| -0.034| 0.49| 0.362|
| Correl(·, Y\(−1\)) | 0.306| 0.209| 0.428| 0.206| 0.340| 0.223|
| Correl(·, Y\(−2\)) | 0.375| 0.364| 0.397| 0.390| 0.433| -0.283|
| Correl(·, CNDS)   | 0.217| 0.104| 0.263| -0.056| 0.016| -|
| Correl(·, CNDS\(−1\)) | 0.302| 0.199| 0.430| 0.150| 0.292| -|
| Correl(·, CNDS\(−2\)) | 0.320| 0.381| 0.438| 0.446| 0.480| -|

Notes: Data source is NIPA data from the BEA. All variables are annual, the sample goes from 1960-2006. They are deflated by their corresponding deflators, logged and filtered with a Hodrick-Prescott filter with smoothing parameter 6.25. ‘GSLC’ stands for state and local government consumption. ‘GNDC’ denotes total non-defense consumption, ‘GND’ total non-defense purchases and ‘GC’ total government consumption. ‘G’ is total government purchases. ‘Correl(·, Y)’ denotes the contemporaneous correlation with aggregate GDP, ‘Correl(·, Y\(−1\))’ and ‘Correl(·, Y\(−2\))’ the correlation with aggregate GDP one and two years lagged, respectively. ‘CNDS’ stands for non-durable and services consumption.

State and local government consumption belongs by definition to the non-defense category, which is a plausible candidate for non-exogenous expenditures.\(^3\) Focussing on the state and local level allows us to abstract from government debt, which would complicate the model and the computation considerably. Furthermore, ‘GSLC’ is roughly 10 percent of GDP and slightly under 50 percent of total government purchases, which makes it the largest individual category at this level of disaggregation. On the other hand, Table 1 also shows that the important

\(^3\)See the structural vector autoregressions literature which takes the same view and often using military purchases to identify exogenous government spending shocks.
business cycle facts for state and local government consumption can also be found in other aggregates, such as non-defense public consumption, non-defense purchases, total public consumption and total government purchases.\footnote{Table 7 in the Appendix shows that this is also true for a functional disaggregation.} We view this as evidence that the causes of the business cycle of government purchases should be sought in aggregate factors.

We use the Hodrick-Prescott filter with a smoothing parameter of 6.25 (see Ravn and Uhlig, 2002) to capture very narrowly the business cycle dynamics of government purchases. Bachmann and Bai (2011) argues that government purchases also have important medium-frequency dynamics that we want to exclude here. Table 6 in the Appendix indeed shows, using a band-pass filter which lets through frequencies from 2 to 8 years, that we get similar results to the HP(6.25) filter. Finally, Figures 1 to 3, using data from the Annual Survey of State Government Finances, show that the dynamic correlation pattern for aggregate state and local government consumption with output also holds for most U.S. states individually.

This evidence taken together leads us to treat the four properties of GSLC from the beginning of this section as new stylized business cycle facts. They are also suggestive of some of the model ingredients we need in the quantitative exercise that follows. The fact that the dynamic correlogram between public consumption and output or private consumption is tilted towards public consumption lagging the cycle suggests implementation lags. We will show that without a second shock a representative agent model will always overshoot the level of the correlogram (see Bachmann and Bai, 2011, for an alternative story in a heterogeneous agent framework). Finally, persistence suggests the budget implementation costs we use.

\section{The Model}

The basic environment is a representative household one-sector growth model with government consumption. The government finances the provision of public goods with a flat rate income tax and adheres to a balanced budget rule. The government cannot commit ex ante to a stream of future government policy. Government consumption is chosen to maximize the welfare of the representative household. The equilibrium is subject to a time-consistency requirement.

\subsection{The Economic Environment}

The economy is populated by a unit mass continuum of infinitely lived identical households. In each period, the household is endowed with $\tilde{t}$ units of time. She values private consumption, $c$,
leisure, $l - l$, and government consumption, $G$, according to the following felicity function:

$$u(c, l, G) = \eta \left( \theta \log(c) + (1 - \theta) \log(1 - l) \right) + (1 - \eta) \log(l - l). \tag{1}$$

Life time utility follows the standard expected utility form with a discount factor $\beta$. $\theta$, the parameter that governs the relative preferences for private consumption versus public consumption, is assumed to be time-varying. We interpret this as an (aggregate) taste shock. Specifically, we assume that $\theta$ follows a two-state symmetric Markov chain with support $[1 - \epsilon \theta, 1 + \epsilon \theta]$ and transition matrix $(\rho \theta, 1 - \rho \theta)$. $\epsilon \theta$ governs the volatility of this process, $\rho \theta$ its persistence.

Notice that with a time-varying $\theta$ we implicitly assume here that the relative taste shock is primarily between private and public consumption with an indirect leisure effect. We use this formulation as our baseline case.\footnote{With three commodities in the felicity function there is another formulation where the taste shock is between the private bundle including leisure and public consumption. We explore this specification in Section 4.3: $u(c, l, G) = \theta \left( \eta \log(c) + (1 - \eta) \log(l - l) \right) + (1 - \theta) \log(G)$.}

The household owns capital, $k$, and rents it out in a perfectly competitive market. Capital depreciates at rate $\delta$. The budget constraint of the household is given by:

$$c + k' = (1 - \delta) k + (1 - \tau) (wl + rk), \tag{2}$$

where $k'$ is capital carried over to the next period, $\tau$ the flat income tax rate, $w$ the real wage and $r$ the rental rate for capital. $k'$ is restricted to lie in $[0, +\infty)$.

Aggregate output, $Y$, is produced by a representative firm according to an aggregate Cobb-Douglas production function: $Y = z K^\alpha L^{1 - \alpha}$, where $K$ and $L$ are aggregate capital stock and labor, respectively. $z$ is aggregate productivity and the second source of aggregate uncertainty in this economy. Its natural logarithm evolves according to a Gaussian AR(1) process. 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: $w(K, L, z) = (1 - \alpha) (K/L)^\alpha$ and $r(K, L, z) = \alpha z (K/L)^{\alpha - 1}$.

Government consumption is decided one period ahead. We assume that the current government is legally bound by this decision and in this sense there is a one-period-ahead commitment. This feature captures implementation lags in the budgetary process. In addition, the budget authority pays a quadratic adjustment cost for changing next period’s government consumption. Both government consumption of the current period and the adjustment costs are financed by the flat tax on current income through a balanced budget requirement, as is
typically the case for most U.S. states.

\[ \tau Y = G + \frac{\Omega}{2} (G' - G)^2. \] (3)

The flat income tax rate is then implicitly defined as a function of \((K, L, z, G, G')\):

\[ \tau(K, L, z, G, G') = \frac{G + \frac{\Omega}{2} (G' - G)^2}{z K^a L^{1-a}}. \] (4)

Aggregate output is used for private and public consumption, plus budget adjustment costs, as well as private investment:

\[ C + G + \frac{\Omega}{2} (G' - G)^2 + K' = (1 - \delta) K + z K^a L^{1-a}. \] (5)

### 3.2 Equilibrium with Endogenous Public Policy

Tomorrow’s government consumption is chosen to maximize the welfare of the representative household. In deciding tomorrow’s \(G\), the government does not have commitment power into the future beyond tomorrow. Without a commitment device, it is well known that the commitment equilibrium in our environment is not time-consistent. Time consistency thus requires imposing a subgame-perfect restriction with successive governments and the households as game players. Following KKR, we focus on a subclass of subgame-perfect equilibrium with Markov strategies, i.e., Markov-Perfect Equilibrium (MPE). The formal definition follows.

**Definition 1** A Markov-Perfect Equilibrium for the economy is a set of functions, including a government policy function \(G' = \Psi(K, G, z, \theta, G')\), a transition function \(K' = H(K, G, z, \theta, G')\), an aggregate labor supply function \(L(K, G, z, \theta, G'; \Psi, H)\), an equilibrium continuation value function \(v(k, K, G, z, \theta; \Psi, H)\), a best-response value function \(J(k, K, G, z, \theta; G'; \Psi, H)\) and a best-response decision rule \(k' = h(k, K, G, z, \theta; G'; \Psi, H)\) and \(l = l(k, K, G, z, \theta; G'; \Psi, H)\), such that

(a) For any given \(G'\), the value functions and decision rules solve the household problem

\[ J(k, K, G, z, \theta; G'; \Psi, H) = \max_{\{c, l, k'\}} \left\{ u(c, l, G) + \beta E \left[ v(k', K', G', z', \theta'; \Psi, H) | z, \theta \right] \right\} \]

s.t.

\[ c \geq 0, k' \geq 0, 0 \leq l \leq \tilde{l} \]

\[ c + k' = (1 - \delta) k + \left(1 - \tau(K, L, z, G, G')\right)\left[w(K, L, z) l + r(K, L, z) k\right], \]

\[ K' = H(K, G, z, \theta, G'), \]

\[ L = L(K, G, z, \theta, G'; \Psi, H). \]
In addition, \( v(k, K, G, z, \theta; \Psi, H) = J(k, K, G, z, \theta; \Psi, H) \).

(b) \( H(K, G, z, \theta, G') = h(K, K, G, z, \theta, G'; \Psi, H) \) and \( L(K, G, z, \theta, G'; \Psi, H) = l(K, K, G, z, \theta, G'; \Psi, H) \).

(c) \( \Psi(K, G, z, \theta) \) maximizes the welfare of the representative household on the equilibrium path, i.e.,

\[
\Psi(K, G, z, \theta) = \arg\max_{G'} \left\{ J(K, K, G, z, \theta, G'; \Psi, H) \right\},
\]

(6)

The first part of the equilibrium definition says that the household decision rules should be the best response to an arbitrary change in \( G' \) 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 \( G' = \Psi(K, G, z, \theta) \). The second part requires that the evolution of the aggregate capital stock and labor supply are both generated by the households’ best responses. This reflects rational expectations on the household side for both the on and off-equilibrium path. On the equilibrium path, this requirement reduces to the familiar consistency restriction in a Recursive Competitive Equilibrium. The third part specifies the rule for the policy choice.

3.3 Computation and Calibration

We use numerical methods to characterize and analyze the Markov-Perfect equilibrium of the specified economy. As already intimated in the equilibrium definition, we use a global method to iterate on the capital transition function and policy rule \((H, \Psi)\) until a fixed point is reached. The computed fixed point of \( H \) takes the following form:

\[
\log K' = a_0(z, \theta) + a_1(z, \theta) \log K + a_2(z, \theta) \log G + a_3(z, \theta) \log G' + a_4(z, \theta)(\log G')^2 + a_5(z, \theta)(\log G')^3 + a_6(z, \theta) \log G \log G';
\]

(7)

and that of \( \Psi \) takes the form of

\[
\log G' = b_0(z, \theta) + b_1(z, \theta) \log K + b_2(z, \theta) \log G.
\]

(8)

Notice that these functions depend on the level of aggregate productivity and the state of relative demand for public versus private consumption. As for the functional form in (7), we started with a simple log-linear rule instead of (7), but found the \( R^2 \) to be somewhat low, at least for some parameter values. After some experimentation, (7) turned out to be a good compromise
between numerical stability and accuracy. Notice that $H$ has to have good predictive power not only on-equilibrium, but also for a grid of off-equilibrium proposals for $G'$.

We set the output elasticity of capital, $\alpha = 0.36$ and the labor scale $\tilde{l} = 1$. For other parameters, the model is calibrated to match important features of the U.S. economy from 1960 to 2006. Annual data on government consumption 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, $\delta$, is set to 0.1; the discount rate, $\beta$, is fixed at 0.96. Following Tauchen (1986), we model aggregate productivity, $z$, as a five-state Markov chain that approximates a Gaussian log-AR(1) process with an autocorrelation coefficient of 0.8145 (i.e., 0.95 to the power of four.) and - in the baseline calibration - conditional standard deviation of 0.0123. This standard deviation is chosen to make our models approximately match the annual percentage standard deviation of GDP in the data, 1.34%. 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 consumption dynamics (and other components of aggregate demand), given the correct output volatility.

The two parameters in the felicity function are calibrated as follows: $\theta = 0.8512$, the love-of-private-consumption parameter is picked to match the time-averaged $\frac{G}{Y}$-ratio based on aggregate state and local government consumption; $\eta$, the parameter specifying the relative weight between the private-public-consumption-composite and leisure, is chosen to match the average labor hours 0.33. For the aforementioned reasons (see Section 2), we choose to target the $\frac{G}{Y}$-ratio based on aggregate state and local government consumption, i.e. roughly 10.2%.

Three non-standard parameters remain to be calibrated, $\rho_\theta$, $\epsilon_\theta$ and $\Omega$. We fix $\rho_\theta$ at 0.75, which means that a given taste for government consumption remains operative for four years on average. $\epsilon_\theta$ and $\Omega$ are chosen to minimize a weighted quadratic form in the following summary statistics for the dynamics of public and private consumption: the standard deviations and first-order autocorrelations of public and private consumption; the contemporaneous and one- and two-year lagged correlations of public consumption with output and private consumption and the contemporaneous and one-year lagged correlations between private consumption and GDP. These statistics (numbers can be found in Table 1.) summarize the joint business cycle dynamics of public and private consumption as well as GDP very well.
4 Results

4.1 Main Result

Table 2 summarizes two of our main results. The ‘Simple Model’ with no implementation lags or costs and only aggregate productivity shocks can generate the volatility of public consumption in the data. However, such a model delivers basically no persistence and the wrong correlogram. The ‘Baseline Model’ with an implementation lag and calibrated implementation costs as well as a taste shock does substantially better in matching the data.6

Table 2: Baseline Result

| Business Cycle Moment | Baseline Model | Simple Model | Data |
|-----------------------|---------------|--------------|------|
| $std(G)$              | 0.699         | 0.737        | 0.783|
| $rho(G)$              | 0.230         | 0.076        | 0.296|
| $correl(G,Y)$         | -0.136        | 0.983        | 0.003|
| $correl(G,Y_{-1})$    | 0.564         | 0.137        | 0.306|
| $correl(G,Y_{-2})$    | 0.307         | -0.175       | 0.375|
| $correl(G,C)$         | 0.184         | 0.970        | 0.217|
| $correl(G,C_{-1})$    | 0.300         | -0.018       | 0.302|
| $correl(G,C_{-2})$    | 0.121         | -0.317       | 0.320|
| $std(C)$              | 0.569         | 0.475        | 0.705|
| $rho(C)$              | 0.124         | 0.174        | 0.362|
| $correl(C,Y)$         | 0.838         | 0.933        | 0.862|
| $correl(C,Y_{-1})$    | 0.258         | 0.289        | 0.223|

Notes: The ‘Baseline Model’ features both a one-year implementation lag and implementation costs ($\Omega = 15$), $\epsilon_\theta = 0.005$. The ‘Simple Model’ has no implementation lags or costs, $\epsilon_\theta = 0$. All time series for both actual and model-simulated data are logged and HP(6.25)-filtered. Public consumption in the data refers to ‘GSLC’ (state and local government consumption). Private consumption in the data refers to ‘CNDS’ (nondurable and services consumption). ‘std’ denotes the standard deviation and ‘rho’ the first-order autocorrelation of the corresponding time series.

Table 3 illustrates our third main result, the variance decomposition. When we run models with the same parametrization as the ‘Baseline Model’, but shut down, respectively, the taste shocks between private and public consumption and the aggregate productivity shocks, we generate, respectively, 41% and 49% of the variance of public consumption in the ‘Baseline Model’. That these variances do not quite add up to unity is indicative of small endogenous interaction effects in the joint response of public consumption to these shocks.

6Table 8 in the Appendix shows that the ‘Baseline Model’ also does well in matching the same statistics, when we replace public and private consumption with their respective ratios over aggregate output.
Table 3: Variance Decomposition - Baseline Model

|                      | Contrib. of z-shocks | Contrib. of θ-shocks | Both   |
|----------------------|-----------------------|----------------------|--------|
|                      | 40.82%                | 49.49%               | 90.31% |

Notes: see notes to Table 2. The first column displays the fraction of the time series variance of public consumption in the ‘Baseline Model’, when the θ-shocks are shut down, but the model is parameterized the same otherwise. The second column shuts down the aggregate productivity shocks. The third column is simply the sum of these variances.

4.2 Explaining the Mechanism

How do the various elements of the baseline model – implementation lags and costs as well as taste shocks between private and public consumption – contribute towards the baseline result? We address this question in two steps: Table 4 stays within the class of models with implementation lags, but, one step at a time, removes implementation costs and the taste shocks for public consumption from the baseline calibration, keeping all other parameters fixed. Table 5 then shows how models without implementation lags fail to reproduce the initially increasing correlogram between public consumption and output/private consumption in the data, even when they are recalibrated to minimize the same quadratic form as the baseline calibration in the twelve business cycle statistics of public and private consumption we focus on.

Starting from the fifth column in Table 4 we see that a model with no implementation costs and only aggregate productivity shocks fails to match the data in two important dimensions. The model delivers no persistence of public consumption and overstates the level of the dynamic correlation between public consumption and lagged private consumption/output. It does do a good job in producing the right amount of volatility for public consumption. Introducing the taste shocks (column four) into the economy remedies the second failure, but worsens the persistence problem and leads to excess volatility in public consumption. Conversely, introducing budget implementation costs only (column three) fixes persistence and somewhat the oversynchronisation issue between public consumption and the other macroeconomic aggregates, but worsens volatility. Combining both features leads to a model that matches the data reasonably well.

This is interesting for two reasons: the fact that the “simpler” model in column five gets the volatility of public consumption approximately right, but fails in two dimensions shows that within the class of models studied both additional features – implementation costs and taste shocks – are required by the data. Secondly, the physical environment studied here features a standard amplification-propagation trade-off: the additional shock makes public consumption more volatile but less persistent, while implementation costs have the opposite effect. There
Table 4: The Impact of Implementation Costs and Taste Shocks

| Business Cycle Moment | Baseline Model | No Taste Shock | No Implementation Costs | No Taste Shock - No Implementation Costs | Data |
|-----------------------|----------------|---------------|-------------------------|------------------------------------------|------|
| std(G)                | 0.699          | 0.446         | 1.221                   | 0.707                                    | 0.783|
| rho(G)                | 0.230          | 0.322         | -0.013                  | 0.085                                    | 0.296|
| correl(G, Y)          | -0.136         | -0.204        | -0.059                  | -0.052                                   | 0.003|
| correl(G, Y_{-1})     | 0.564          | 0.841         | 0.568                   | 0.974                                    | 0.306|
| correl(G, Y_{-2})     | 0.307          | 0.461         | 0.096                   | 0.149                                    | 0.375|
| correl(G, C)          | 0.184          | 0.154         | 0.150                   | 0.248                                    | 0.217|
| correl(G, C_{-1})     | 0.300          | 0.964         | 0.163                   | 0.965                                    | 0.302|
| correl(G, C_{-2})     | 0.121          | 0.361         | 0.025                   | -0.003                                   | 0.320|
| std(C)                | 0.569          | 0.511         | 0.564                   | 0.505                                    | 0.705|
| rho(C)                | 0.124          | 0.180         | 0.115                   | 0.165                                    | 0.362|
| correl(C, Y)          | 0.838          | 0.931         | 0.839                   | 0.935                                    | 0.862|
| correl(C, Y_{-1})     | 0.258          | 0.295         | 0.239                   | 0.277                                    | 0.223|

Notes: see notes to Table 2. The ‘Baseline Model’ features both a one-year implementation lag and implementation costs (Ω = 15), ε_θ = 0.005. The ‘No Taste Shock’ model is identical to the ‘Baseline Model’, but sets ε_θ = 0. The ‘No Implementation Costs’ model is identical to the ‘Baseline Model’, but sets Ω = 0. The ‘No Taste Shock - No Implementation Costs’ model is a combination of columns three and four.

is, however, a priori no reason to believe that this trade-off can be reconciled with the data in a way that the dynamic oversynchronisation of public consumption and the overall cycle is sufficiently, but not too much dampened.

We next study the role of implementation lags. The government now decides about G, not G’. This leads to the following change in the government flow budget constraint:7

$$\tau Y = G + \frac{\Omega}{2} (G - G_{-1})^2.$$  (9)

Table 5 shows – when we compare the third and the fourth column – that implementation lags have a similar role to implementation costs, although their main effect is to get the rough shape of the correlogram between public consumption and private consumption/output right. Column three displays the results of a model simulation where current G is decided on in the current period, but the parameters for implementation costs and the standard deviation of the taste shock are fixed at their baseline values. Without implementation lags the volatility of pub-

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7G_{-1} denotes last period’s public consumption. Notice that for the computation the public consumption that was decided on last period still remains a state variable as long as Ω > 0. Therefore, in the definition of the equilibrium and the Krusell and Smith rules G replaces G’ and G_{-1} replaces G as long as Ω > 0. If Ω = 0, then we have one state variable (G_{-1}) less.
lic consumption shoots up, its persistence goes down and any correlation with private consumption at all horizons is eliminated. From this result it can be expected that recalibration of $\Omega$ and $\epsilon_\theta$ to match the same weighted quadratic form as the baseline calibration in the twelve business cycle moments we focus on, but under the assumption of no implementation lags, will lead to a combination of higher implementation costs and/or lower variance of the taste shock. This is indeed the case: the recalibrated model (column two) has $\Omega = 25$ and $\epsilon_\theta = 0.004$. This model gets the volatility and persistence of public consumption right, even a little better than the baseline model, but fails to deliver the dynamic correlogram between public consumption and other macroeconomic aggregates qualitatively.

### Table 5: The Role of Implementation Lags

| Business Cycle Moment | No Implementation Lag Recalibrated | No Implementation Lag Param. from Baseline | Baseline Model | Data |
|-----------------------|-----------------------------------|------------------------------------------|----------------|------|
| std($G$)              | 0.718                             | 1.033                                    | 0.699          | 0.783|
| rho($G$)              | 0.257                             | 0.193                                    | 0.230          | 0.296|
| correl($G, Y$)        | 0.387                             | 0.322                                    | -0.136         | 0.003|
| correl($G, Y_{-1}$)   | 0.280                             | 0.202                                    | 0.564          | 0.306|
| correl($G, Y_{-2}$)   | 0.070                             | 0.030                                    | 0.307          | 0.375|
| correl($G, C$)        | 0.178                             | -0.031                                   | 0.184          | 0.217|
| correl($G, C_{-1}$)   | 0.122                             | 0.034                                    | 0.300          | 0.302|
| correl($G, C_{-2}$)   | 0.019                             | 0.036                                    | 0.121          | 0.320|
| std($C$)              | 0.537                             | 0.562                                    | 0.569          | 0.705|
| rho($C$)              | 0.142                             | 0.116                                    | 0.124          | 0.362|
| correl($C, Y$)        | 0.851                             | 0.823                                    | 0.838          | 0.862|
| correl($C, Y_{-1}$)   | 0.277                             | 0.253                                    | 0.258          | 0.223|

Notes: see notes to Table 2. The second column shows the results of a model where public consumption is decided on contemporaneously, but implementation costs and the volatility of the relative taste shock between private and public consumption have been calibrated to the same quadratic form as the ‘Baseline Model’: $\Omega = 25$, $\epsilon_\theta = 0.004$. The third column shows the results of a model where public consumption is decided on contemporaneously, but the implementation costs parameter and the volatility of the relative taste shock are set equal to the ‘Baseline Model’: $\Omega = 15$, $\epsilon_\theta = 0.005$.

### 4.3 Alternative Model Specifications

### 5 Conclusion

We document the business cycle behavior of various subaggregates of government purchases, in particular state and local government consumption. We provide a tractable workhorse model
that is as close as possible to standard quantitative macroeconomic models in order to match
important business cycle features of public consumption. We argue that both implementa-
tion lags and implementation costs in the budgeting process plus taste shocks for public con-
sumption relative to private consumption are essential to generate this match. We then use this
model to decompose the variance of public consumption into fluctuations that are endogenous
responses of the policy maker to changing macroeconomic conditions and direct taste shocks
in the populace between private and public consumption. In our baseline calibration we have
that 40 percent of the variance of public consumption is explained by aggregate productivity
shocks. Some model features used here are rather stylized and need a better microfoundation.
We view this paper as a first step into using quantitative macroeconomic reasoning to explain
observed fluctuations of public policy variables.
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### Appendix

**Table 6: Business Cycle Facts of Government Purchases - Bandpass Filter (2,8)**

| Moment                  | GSLC | GNDC | GND | GC  | G   | CNDS |
|-------------------------|------|------|-----|-----|-----|------|
| Standard Dev.           | 0.719| 0.742| 0.871| 1.041| 1.195| 0.627|
| 1st-order Autocorrel.   | 0.243| 0.170| 0.335| 0.450| 0.512| 0.289|
| Correl(. , Y)           | -0.122| -0.138| 0.131| -0.066| 0.024| 0.856|
| Correl(. , Y_{-1})      | 0.254| 0.252| 0.427| 0.245| 0.381| 0.121|
| Correl(. , Y_{-2})      | 0.413| 0.453| 0.495| 0.425| 0.476|-0.398|
| Correl(. , GSC)         | 0.051| -0.015| 0.158| -0.074| -0.008|-   |
| Correl(. , CNDS{-1})    | 0.202| 0.195| 0.399| 0.105| 0.263|-   |
| Correl(. , CNDS{-2})    | 0.377| 0.483| 0.547| 0.400| 0.457|-   |

**Notes:** Data source is NIPA data from the BEA. All variables are annual, they range from 1960-2006. They are deflated by their corresponding deflators, logged and filtered with a Bandpass Filter that defines business cycle frequencies from 2 to 8 years. *GSLC* stands for state and local government consumption. ‘GNDC’ denotes total non-defense consumption, ‘GND’ total non-defense purchases and ‘GC’ total government consumption. ‘G’ is total government purchases. ‘Correl(. , Y)’ denotes the contemporaneous correlation with aggregate GDP ‘Correl(. , Y_{-1})’ and ‘Correl(. , Y_{-2})’ for the correlation with aggregate GDP one and two years lagged, respectively. ‘CNDS’ stands for nondurable and services consumption.
Table 7: **Business Cycle Facts of Government Purchases - Functional Disaggregation**

| Moment                       | Autocorr. 1st-order | Correl(·, Y) | Correl(·, Y<sub>-1</sub>) | Correl(·, Y<sub>-2</sub>) | Frac. of GSL |
|------------------------------|---------------------|--------------|-----------------------------|-----------------------------|--------------|
| General public service       | 0.316               | 0.050        | 0.190                       | 0.2138                      | 10.72 %      |
| Public order and safety      | -0.021              | -0.091       | 0.308                       | 0.501                       | 13.90 %      |
| Economic affairs             | 0.481               | 0.450        | 0.455                       | 0.059                       | 19.40 %      |
| Transportation               | 0.466               | 0.489        | 0.371                       | -0.002                      | 15.17 %      |
| Other economic affairs       | 0.107               | 0.163        | 0.486                       | 0.208                       | 4.20 %       |
| Housing & comm. serv.        | 0.037               | 0.003        | 0.266                       | 0.600                       | 3.77 %       |
| Health                       | 0.004               | -0.348       | 0.014                       | 0.179                       | 3.51 %       |
| Recreation and culture       | 0.219               | -0.290       | 0.348                       | 0.490                       | 1.98 %       |
| Education                    | 0.477               | 0.264        | 0.459                       | 0.334                       | 42.98 %      |
| Elementary and secondary     | 0.460               | 0.235        | 0.349                       | 0.350                       | 34.90 %      |
| Higher                       | 0.083               | 0.238        | 0.496                       | 0.076                       | 6.57 %       |
| Libraries and other          | 0.190               | 0.090        | 0.365                       | 0.336                       | 1.76 %       |
| Income security              | 0.198               | 0.205        | 0.117                       | -0.049                      | 3.88 %       |

**Notes:** Data source is NIPA data from the BEA. All variables are annual, the sample goes from 1960-2006. They are deflated by their corresponding deflators, logged and filtered with a Hodrick-Prescott filter with smoothing parameter 6.25. 'Correl(·, Y)' denotes the contemporaneous correlation with aggregate GDP, 'Correl(·, Y<sub>-1</sub>)' and 'Correl(·, Y<sub>-2</sub>)' for the correlation with aggregate GDP one and two years lagged, respectively. 'Frac. of GSL' denotes the fraction of the corresponding aggregate with respect to total state and local government purchases (there is not consumption/investment distinction in the functional disaggregation). 'Housing & comm. serv.' stands for 'Housing and community services'.
Figure 1: Contemporaneous Correlation of GDP and Public Consumption by State

Notes: Real GDP by state is taken directly from the BEA. Public consumption is the total ‘Total Current Operations’ category from the Annual Survey of State Government Finances from the Census, which we deflate by a state-specific deflator for government purchases, computed from BEA data on total nominal and real government purchases. All variables are annual, the sample goes from 1977-2006. They are logged and filtered with a Hodrick-Prescott filter with smoothing parameter 6.25.
Figure 2: Dynamic Correlation of GDP (one year lagged) and Public Consumption by State

Notes: see notes to Figure 1.

Figure 3: Dynamic Correlation of GDP (two years lagged) and Public Consumption by State

Notes: see notes to Figure 1.
Table 8: Baseline Result - Statistics for $\frac{G}{Y}$- and $\frac{C}{Y}$-Ratios

| Business Cycle Moment | Baseline Model | Data  |
|-----------------------|----------------|-------|
| $std(\frac{G}{Y})$    | 0.271          | 0.608 |
| $\rho(\frac{G}{Y})$  | 0.494          | 0.900 |
| $correl(\frac{G}{Y}, Y)$ | -0.697    | -0.283 |
| $correl(\frac{G}{Y}, Y_{-1})$ | 0.090     | -0.050 |
| $correl(\frac{G}{Y}, Y_{-2})$ | 0.263     | 0.152 |
| $correl(\frac{G}{Y}, C)$ | -0.494    | -0.131 |
| $correl(\frac{G}{Y}, C_{-1})$ | 0.151     | -0.057 |
| $correl(\frac{G}{Y}, C_{-2})$ | 0.313     | 0.149 |
| $std(\frac{C}{Y})$    | 1.078          | 0.967 |
| $\rho(\frac{C}{Y})$  | 0.562          | 0.701 |
| $correl(\frac{C}{Y}, Y)$ | -0.703    | -0.606 |
| $correl(\frac{C}{Y}, Y_{-1})$ | -0.010    | -0.251 |

Notes: The 'Baseline Model' features both a one-year implementation lag and implementation costs ($\Omega = 15$); $c_0 = 0.005$. All time series for both actual and model-simulated data are linearly detrended. Public consumption in the data refers to 'GSLC' (state and local government consumption). Private consumption in the data refers to 'CNDS' (nondurable and services consumption). 'std' denotes the standard deviation and 'rho' the first-order autocorrelation of the corresponding time series.