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[†] University of Hamburg, Chair of Economics, Von-Melle-Park 5, 20146 Hamburg, Germany. Email: Dennis.Wesselbaum@Wiso.Uni-Hamburg.de

Abstract

This paper shows that government debt creates a so far neglected wealth effect that has sizable effects on business cycle fluctuations. We present a new channel through which governments can influence cyclical fluctuations generated by any type of shock and contribute to macroeconomic stability. We provide evidence for the United States that debt moves procyclical with output. Then, we build a Real Business Cycle model with Non-Ricardian agents and use rules to describe fiscal policy. We show that procyclical debt generates smaller fluctuations compared to countercyclical debt. The striking consequence is that classical Keynesian fiscal policy destabilizes the business cycle in our framework.

Keywords: Debt, Fiscal Rules, Non-Ricardian Agents, SVAR.

JEL codes: E32, E62, H3.

Résumé

Cet article montre que la dette publique crée un effet de richesse, jusqu'à présent négligé, qui exerce une incidence notable sur les fluctuations du cycle conjoncturel. Nous présentons un nouveau canal par lequel les gouvernements peuvent influencer les fluctuations cycliques générées par tout type de choc et contribuer à la stabilité macroéconomique. Nous démontrons qu'aux États-Unis, l'endettement évolue de manière procyclique avec la production. Nous élaborons ensuite un modèle de cycle conjoncturel réel à agents non ricardiens et nous utilisons des règles pour décrire la politique budgétaire. Nous établissons que l'endettement procyclique génère des fluctuations moins prononcées que l'endettement contracyclique. De façon saisissante, il en résulte que dans ce cadre, la politique budgétaire keynésienne classique déstabilise le cycle conjoncturel.

Mots-clés : Dette, Règles budgétaires, Agents non ricardiens, SVAR.

Classification JEL : E32, E62, H3.

1 Introduction

In this paper, we build an otherwise canonical real business cycle model of the U.S. economy with Non-Ricardian agents. We use a perpetual-youth structure following the work of Blanchard (1985) and Yaari (1965) to break the Ricardian equivalence and fiscal rules to characterize the behavior of the fiscal authority. Those rules describe the evolution of taxes and government spending over the cycle and feature feedback on government debt and output. Therefore, they capture two major incentives for fiscal authorities, viz. to stabilize business cycle fluctuations and to keep debt on a sustainable path. Further, fiscal rules are tools that allow us to generate pro- and countercyclical government debt.

The main contribution of this paper is theoretical. We show that government debt, as being a component of household's financial wealth, creates an additional wealth effect that has sizable effects on the business cycle. We interpret this channel as an additional automatic stabilizer of economic activity. Therefore, we present a new channel through which governments can influence cyclical fluctuations and contribute to macroeconomic stability.[1] This channel emerges from combining Blanchard (1985) -Yaari (1965) consumers and fiscal rules. The former implies that debt affects household decisions and the latter allows debt to be a function of output. The striking and provocative consequence is that classical (countercyclical) Keynesian fiscal policy destabilizes the business cycle in this basic framework. Remarkably, this channel plays a role for the propagation of all shocks that affect output and, hence, is important even in the absence of exogenous fiscal policy innovations.

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[1] Woodford (1995) uses a similar, though conceptionally different, effect in the *fiscal theory of the price level.* Changes in the real value of government debt generate changes in the lifetime budget constraint of private agents, i.e. a wealth effect, that drives aggregate demand. However, this only holds iff policy is "Non-Ricardian", that is to say that agents expect that the government does not adjust future budgets to neutralize this effect. In contrast, the channel presented in this paper does not rely on the violation of future government's budget constraints. The reason is that the Ricardian equivalence is broken by household's behavior and not by the government's policy.

In detail, the contribution of this paper is twofold. First, we present robust empirical evidence on the long-run relation of output and debt in the United States and estimate the parameters of the fiscal rules. We estimate a structural VAR model identified by long-run restrictions to shed light on the relation between output and debt conditional on technology shocks. We do so because, empirically, technology shocks are main drivers of business cycles and are predominantly used in the Real Business Cycle (RBC, for short) paradigm. Our findings show that government debt is procyclical in output.

Second, we show that in our model, countercyclical debt creates larger volatilities of key macroeconomic variables and is hence destabilizing. This finding contradicts the canonical view of Keynesian fiscal policy as being able to counter adverse effects of economic recessions and, hence, stabilize the economy.

In order to develop some intuition for our result, assume that our economy is hit by a positive, mean-reverting technology shock. This shock will increases output and - as we have learned from our empirical exercise - government debt will co-move with output. As debt increases, households feel richer, because debt is net wealth in the perpetual-youth model. Consistently, this wealth effect affects the households' consumption-leisure decision and the labor supply schedule is shifted inwards, such that agents supply less labor. Fiscal policy can affect the size of the wealth effect steaming from the change in debt, namely by putting different weights on their two goals. We provide a robustness check on the parameters in the fiscal rule and document which parameter values would generate the procyclical result of low volatilities.

Finally, we would like to stress that our channel is not present in the standard Ricardian agent RBC model, such that in this environment fiscal policy has only negligible effects on the propagation of technology shocks.

The paper is structured as follows. The next section estimates the SVAR model and presents our empirical evidence. Section 3 develops the model while Section 4 discusses the differences between pro- and countercyclical fiscal policy. Finally, Section 5 briefly concludes.

2 Empirical Evidence

This section provides empirical evidence about the long-run relation between output and debt over the U.S. business cycle.[2] We estimate a bivariate structural VAR with output and government debt using an $\mathbf{A}-\mathbf{B}$ model with long-run restrictions according to Galí (1992) and Breitung et al. (2004).

Our approach can be motivated by two observations. First, we are interested in the relation between output and debt conditional on a technology shock, as technology shocks are main drivers of business cycle fluctuations, see e.g. Fisher (2002) or Christiano et al. (2003). Therefore, we will feed a technology shock through the RBC model developed later in this paper to discuss the business cycle implications of the new channel we are emphasizing. As a consequence, we impose the restriction that output shocks do have long-run effects and shocks to government debt do not have long-run effects on output.

Further, empirical evidence has shown that at least some technology shocks have a unit root (see e.g. Galí (1999) or Shea (1999)), hence, they will affect the level of output in the long-run. Therefore, at least some of the innovations to output - we think of those technology shocks here or, more generally, supply-side shocks - will have permanent effects. This is the key assumption underlying our identifying restriction. Since

Second, besides characterizing the long-run dynamics of output and debt, we aim at estimating

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[2] Details on the data and the estimations can be found in a technical appendix available upon request. Our results are robust to using a SVAR in output, debt, government spending, and taxes.

the parameters of fiscal rules. We will use those rules later on in our model to replicate the observed debt dynamics and discuss the estimation of those rules in the calibration section. Nevertheless, we want to stress that the estimation of rules, inherently, is related to a long-run perspective rather than a short-run one; which supports our identification approach.

Technically, we consider a structural form SVAR(p)

$$\mathbf{A}y_t = \sum_{i=0}^{p} A_i^* y_{t-i} + \mathbf{B}\varepsilon_t, \tag{1}$$

where y_t is a $(K \times 1)$ vector of observables and u_t is a K-dimensional vector of residuals. Further, $A_i^* = \mathbf{A}A_i$ is a $(K \times K)$ dimensional coefficient matrix for all $i = 1, \ldots p$. We impose an additional assumption that allows us to identify the structural innovations ε_t from the reduced form residuals u_t

$$\mathbf{A}u_t = \mathbf{B}\varepsilon_t, \tag{2}$$

where $\varepsilon_t \sim (0, \mathbf{I}_K)$ is Gaussian white noise and the covariance matrix is $\Sigma_u = \mathbf{A}^{-1}\mathbf{B}\mathbf{B}^T \left[\mathbf{A}^{-1}\right]^T$.

We need to impose $2K^2 - \frac{1}{2}K\left(K+1\right)$ restrictions to identify all $2K^2$ parameters of the $\mathbf{A}$ and $\mathbf{B}$ matrix. For large VAR systems the number of restrictions is quite large, which often leads to consideration of special cases, i.e. an $\mathbf{A}$ or $\mathbf{B}$ model. However, given our identification approach and the bivariate structure allows us to use the $\mathbf{A} - \mathbf{B}$ model with the following five restrictions

$$\mathbf{A} = \begin{bmatrix} 1 & 1 \\ * & 1 \end{bmatrix}, \mathbf{B} = \begin{bmatrix} * & 0 \\ 0 & * \end{bmatrix}. \tag{3}$$

Intuitively, the zero restriction on $\mathbf{B}$ implies that debt innovations have no long-run effect on output.

The time series for output and debt are provided by the Bureau of Economic Analysis' NIPA on a quarterly basis from 1960:Q1 to 2008:Q3 (191 observations) for the United States. A first and preliminary look at the data shows that the simple (unconditional) correlation between the linearly detrended time series is 0.17. However, in order not to mistake correlation with causation, we need to have a more careful and systematic look at the relation between those two variables.

Figure 1 presents the impulse response functions for output and debt in response to the identified supply-side shock. Most importantly, we find that output and government debt move procyclical in response to the shock. Our measure of cyclicality is the simple correlation coefficient between the estimated impulse responses. We find that the model implies a correlation of 0.52 between output and debt on the business cycle frequency of 32 quarters.

Finally, let us provide some robustness checks and address the concern that the two variables could be cointegrated. We use a Johansen cointegration test allowing for deterministic and stochastic cointegration. We find that for both specifications of the test, we obtain one cointegrating relationship. This finding implies the presence of a long-run equilibrium relationship between output and debt. As a robustness check for our results, we estimate a SVAR identified by Blanchard and Quah (1989) long-run restrictions, a vector error correction model (VECM, for short), and a structural VECM. For the SVECM, we impose the same restriction as in the SVAR, namely that debt innovations have no long-run effect on output. The estimations shows again a procyclical relation between output and debt. The correlation for the SVAR, VECM, SVECM is 0.57, 0.16, 0.15 respectively. Therefore, we conclude that the procyclicality of debt is a robust finding.

Let us pause at this point and have a look at the related literature. While there is extensive work on the cyclicality of spending and taxes and also on the cyclicality of the budget surplus, there is almost no evidence on the cyclicality of government debt. One exception is the work by Alesina and Marinescu (2008). They use annual panel data from 1964 to 2005 for a set of OECD countries and regress public debt on the output gap using OLS. In contrast to our findings, they find a countercyclical relation that becomes stronger over time for the United States.

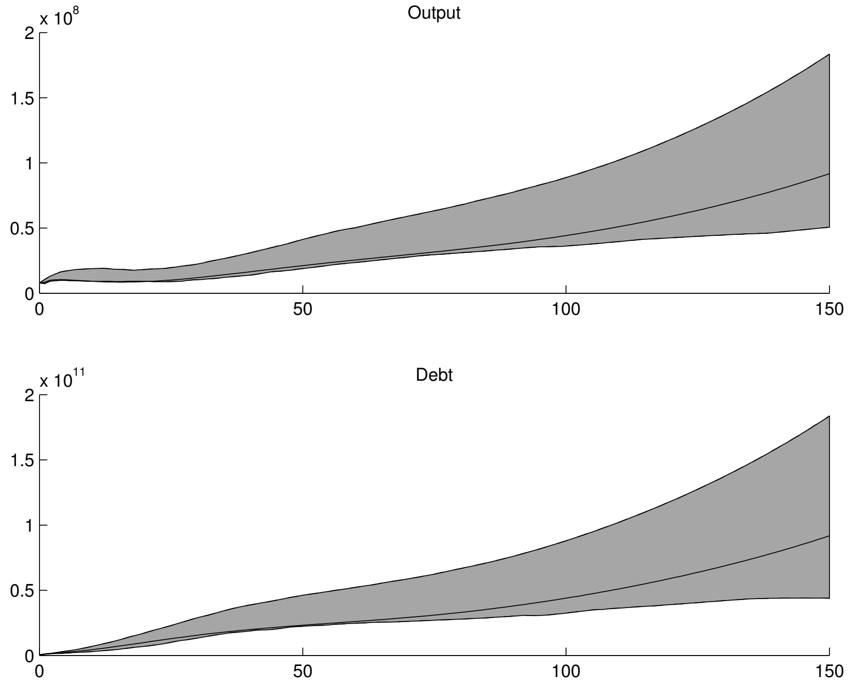

Figure 1: Impulse responses from SVAR estimation. Grey area is the 90 percent bootstrapped confidence interval.

3 The Model

The description of our model economy proceeds in three steps and follows Prescott's narrative approach. First, we define the economy's preferences and technology and we then present the model's assumed market structure. Finally, we conclude by deriving the first-order necessary conditions and by defining the model's equilibrium.

3.1 Preferences and Technology

This section develops a dynamic, micro-founded model of the U.S. economy in discrete time. A period is assumed to be a quarter. Consumption and labor supply decisions are derived along the lines of the discrete time version of the Blanchard (1985) - Yaari (1965) perpetual-youth model.[3]

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[3] The discrete time version of the Blanchard-Yaari model was first developed by Frenkel and Razin (1986).

Firms use a neoclassical production technology with constant-returns to scale to produce output on a perfectly competitive market. Output is produced using capital and labor services. Finally, we assume the presence of convex capital adjustment costs, in order to allow for a variable price of capital as in Christiano et al. (2005). The only source of uncertainty - disregarding the uncertainty about death - in our model is a mean-reverting shock to aggregate technology.

Let us discuss the perpetual-youth structure of our economy. As in Blanchard (1985), we assume that there exists a constant probability of surviving, denoted by $\vartheta > 0$, that each agent faces throughout her lifetime. In turn, this implies an expected lifetime of $(1-\vartheta)^{-1}$. In addition, at any time t, a cohort of size $1-\vartheta$ is born, and total population is normalized to one. Therefore, our economy features a constant population with identical preferences. While agents are of different ages and wealth levels, they all face the same life horizon which implies that they are homogeneous with respect to the marginal propensity to consume. This homogeneity is a necessary condition in order to solve the aggregation problem, as shown by Blanchard (1985).

Perfectly competitive private markets provide insurance risklessly through life insurance companies. Free entry and a zero profit condition imply that agents will pay a rate $1-\vartheta$ to receive one good contingent on their death. Since there is no bequest motive - and since negative bequests are ruled out - agents will contract to have all of their wealth returned to the life insurance company contingent on their death. The insurance company will equally distribute the wealth of the deceased to the survivors, by paying a fair premium.

3.1.1 Households

Given a representative agent out of generation s, let us denote consumption by, C_t^s, and hours worked by, N_t^s, then, the representative agents' preferences are given by the following expected von

Neumann-Morgenstern utility function

$$\Gamma_t = \mathbb{E}_t \left\{ \sum_{j=0}^{\infty} (\vartheta\beta)^j \left[\mathcal{U}_t \left(C^s_{t+j} \right) - \mathcal{V}_t \left(N^s_{t+j} \right) \right] \right\}, \tag{4}$$

where $\mathbb{E}_t$ denotes the expectation conditional on the information available at t and $\beta \in (0,1)$ is the household's discount factor. Agents are assumed to have rational expectations, that is to say, the underlying probability distributions of the conditional mathematical expectations coincide with those implied by the model. Then, the single-period utility function, $\Gamma_0 : \mathbb{R}^2 \rightarrow \mathbb{R}$, satisfies the Inada conditions with goods and leisure, $L^s_t = 1 - N^s_t$, being normal. Furthermore, the utility function is compatible with the requirements of balanced growth. We assume that it is *CRRA* and make further use of the following specifications

$$\begin{aligned} \mathcal{U}_t(\cdot) &= \ln(\cdot), & (5) \\ \mathcal{V}_t(\cdot) &= \frac{(\cdot)^{1+\varphi}}{1+\varphi}, & (6) \end{aligned}$$

where the inverse of the Frisch labor supply elasticity is given by $\varphi > 0$.

Note that we will assume that preferences over consumption are logarithmic for the reminder of this paper, as, for example, in Smets and Wouters (2002). This implies that we can find an intuitive expression for the marginal propensity to consume, which will depend only on the discount factor and the probability of surviving. In the general case of iso-elastic preferences the propensity of consume would depend on the expected real return on financial wealth (which we will explicitly define later on) and, moreover, would depend on the time of birth. Furthermore, as stated by Weil (1989), using utility functions that feature non-logarithmic preferences will offer no additional insight while, most importantly, would make the aggregation problem across the entire population impossible, because consumption would be non-linear in wealth.

3.1.2 Technology

Along the firm side of our economy, a representative firm uses capital, K_t, and labor services, N_t, as inputs for a Cobb-Douglas production function

$$Y_t = Z_t K_t^{\alpha} N_t^{1-\alpha}, \tag{7}$$

here, $\alpha \in [0,1]$ is the capital elasticity in the production function and we denote the aggregate, Hicks-neutral technology shock by Z_t. A first-order autoregressive process determines its evolution

$$\ln Z_t = \rho_Z \ln Z_{t-1} + e_{Z,t}, \tag{8}$$

where $0 < \rho_Z < 1$ determines the degree of autocorrelation and its innovation is i.i.d. over time and Gaussian distributed,

$$e_{Z,t} \sim N\left(0, \sigma_Z\right). \tag{9}$$

Households own the capital stock and rent it to the firm on a perfectly competitive market. The capital accumulation technology is given by

$$K_t = (1-\delta) K_{t-1} + \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t, \tag{10}$$

where I_t is investment and $S(\cdot)$ captures capital adjustment costs as in Christiano et al. (2005), which, in steady state, satisfies $S(\cdot) = 0$, $S'(\cdot) = 0$, and $S''(\cdot) > 0$. We add those adjustment costs in order to replicate more realistic asset price dynamics. This is particularly relevant in this framework as the capital price drives the real value of the capital stock and, therefore, households wealth.[4] Furthermore, $\delta > 0$ denotes the exogenous rate of capital depreciation.

3.1.3 Fiscal Authority

We postulate that our fiscal authority follows a tax and a government spending rule to conduct fiscal policy as, for example, in Leeper et al. (2010a, 2010b). Those rules have endogenous feedback to lagged output and lagged government debt which allows us to model a dynamic response and to cover the two main objectives of fiscal policy.[5]

Let us spend some time to motivate those rules and to derive some intuition. Why should fiscal policy respond to those two variables? First the response to output is the usual automatic stabilizer component of fiscal policy described in the literature (see DeLong and Summers (1986) and Galí (1994)).[6]

Second, the budgetary position of the United States has deteriorated substantially over the past decades. Main driving forces have been short-run events (such as large spending programs and a sharp decline in tax revenues) and long-run trends. The share of the population receiving benefits from Social Security, Medicare, and Medicaid will keep increasing. Along this line, the implementation of fiscal rules with feedback to debt may help to structure the budget process and promote fiscal responsibility by constraining decisions about spending and taxes.

Further, while monetary policy rules, as e.g. the widely used Taylor-type interest rate rule, have been at the center of macroeconomic research, the implications of fiscal policy rules on the business cycle have not been scrutinized that detailed. Leeper and Yang (2008) show that in a stylized real business cycle model the response of the economy crucially depends on which fiscal instruments finances debt. Leeper et al. (2010a) extend this analysis and use Bayesian methods to

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[4] The results are robust to excluding capital adjustment costs.

[5] Robustness checks reveal that our qualitative results are unaffected by assuming a contemporaneous relation.

[6] I wish to make a remark here: the automatic stabilizer component in the fiscal rules should not be mistaken with the (automatic) stabilizing effect of debt.

determine the specifications of fiscal rules that feature endogenous feedback on output and debt.

Formally, our fiscal authority issues bonds, provides government spending (that does not affect the marginal utility of private consumption), and uses lump sum taxes for redistribution purposes. However, only two of those instruments can be set independently, while the third follows from the equilibrium restriction. The equilibrium restriction on the fiscal authority's actions is

$$\frac{B_{t+1}}{R_t} = B_t + G_t - \tau_t. \tag{11}$$

The tax rule can - in log-linearized terms - be written as

$$\hat{\tau}_t = \tau_Y \hat{Y}_{t-1} + \tau_B \hat{B}_{t-1}. \tag{12}$$

Here, $\tau_B \in \mathbb{R}$ is the parameter governing the feedback on debt, and $\tau_Y \in \mathbb{R}$ is the coefficient on output. The former accounts for a debt stabilization goal of the fiscal authority, while the latter takes business cycle movements into account.

Then, we assume that the government spending rule - in log-linearized terms - follows

$$\hat{G}_t = \gamma_Y \hat{Y}_{t-1} + \gamma_B \hat{B}_{t-1}. \tag{13}$$

As before, $\gamma_Y \in \mathbb{R}$ accounts for the business cycle stabilization goal of our government and $\gamma_B \in \mathbb{R}$ captures the aim to stabilize debt.

At the end of this chapter we can draw the conclusion that fiscal policy, defined as the sequence of debt, spending, and taxes, affects the agents optimal allocation problems through three channels. First, debt is part of financial wealth which drives consumption (and leisure decisions). Second, taxes are an important factor for human wealth and therefore have an impact on the consumption/leisure decision. Finally, spending is a component of aggregate demand and therefore directly affects total output produced in our economy.

3.2 Market Structure

The model features four spot markets, namely the bond market, the capital market, the good market, and the labor market, the latter three being perfectly competitive. Then, we follow Mehra and Prescott (1980) and assume that only households own capital between quarters. At the beginning of each quarter, households sell capital to the representative firm. At the quarter's end, the firm sells all capital back to the households.

Furthermore, and confronted with the finiteness of agent's life and the accumulation process of capital, we assume that firms are long-lived. This requires the existence of an underlying stock market in order to pass firm ownership on to new agents. Our firm is a legal entity issuing equity shares, while its ownership is perfectly divisible across an unbounded sequence of finite-lived shareholders (i.e. households).

3.3 Optimization and Equilibrium

Optimization of all agents but the fiscal authority defines equilibrium. We start with the households utility maximization problem and continue with the firms profit maximization problem. We conclude with the aggregation problem and define the model's equilibrium.

3.3.1 Households

We assume that the economy begins with all households having identical financial wealth and consumption histories. This assumption assures that together with the optimal use of the available contingent claims markets, this homogeneity will continue. To be precise, agents have access to a full set of state-contingent Arrow-Debreu securities after their birth. Moreover, this allows us to only consider the consumption and savings decisions of a representative household. The representative household faces the following intertemporal budget constraint

$$\frac{B_{t+1}^s}{R_t} + Q_t K_{t+1}^s \leq A_t^s + W_t N_t^s - T_t^s - C_t^s, \tag{14}$$

where we define financial wealth, A_t^s, by

$$A_t^s = \frac{1}{\vartheta}\left[B_t^s + \left((1-\delta)Q_t + R_t^K\right) K_t^s\right], \tag{15}$$

where Q_t represents the price of capital and R_t^k is the nominal rental rate of capital. In addition, B_t^s is a one-period government bond issued on a discount basis with an interest rate R_t.[7] The agent receives labor income $W_t N_t^s$ and has to pay lump sum taxes T_t^s to the fiscal authority.

Further, there exists a transversality condition that prevents agents from going infinitely into debt

$$\lim_{t\to\infty}\left\{(\vartheta\beta)^t A_t^s\right\} \geq 0. \tag{16}$$

The unique solution to the concave optimization problem, maximizing eq. (4) subject to the constraint (14), is (14) with equality and - assuming that the solution is interior - the marginal conditions for consumption, investment, capital, and hours

$$\begin{aligned}
\partial C_t^s &: \frac{1}{C_t^s} = \zeta_t, && (17)\\
\partial I_t^s &: q_t\left[1 - S\left(\frac{I_t^s}{I_{t-1}^s}\right) - S'\left(\frac{I_t^s}{I_{t-1}^s}\right)\frac{I_t^s}{I_{t-1}^s}\right] + \mathbb{E}_t\left[\beta\frac{\zeta_{t+1}}{\zeta_t} q_{t+1} S'\left(\frac{I_t^s}{I_{t-1}^s}\right)\left(\frac{I_{t+1}^s}{I_t^s}\right)^2\right] = 1, && (18)\\
\partial K_t^s &: q_t = \mathbb{E}_t\left\{\beta\frac{\zeta_{t+1}}{\zeta_t}\left[R_{t+1}^K + q_{t+1}(1-\delta)\right]\right\}, && (19)\\
\partial N_t^s &: -\left(N_t^s\right)^{\varphi} + \zeta_t W_t = 0. && (20)
\end{aligned}$$

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[7] In the United States, the maturity structure of government debt is fairly short: the median number is roughly two years.

Here, ζ_t, is the Lagrangian multiplier on the budget constraint. Now, let us define H_t^s as human wealth given by

$$H_t^s = h_t^s + \mathbb{E}_t \left\{ \sum_{j=1}^{\infty} \vartheta^j \left[\prod_{k=0}^{j-1} \frac{1}{R_{t+k}} \right] h_{t+j}^s \right\}, \tag{21}$$

where we use $h_t^s = W_t N_t^s - T_t^s$. Human wealth can be interpreted as the expected, discounted stream of labor incomes and profits net of taxes.

In the next step, the budget constraint can be re-written as

$$A_{t+1}^s = R_t \left[A_t^s - C_t^s + h_t^s \right]. \tag{22}$$

Solving this equation forward and using the Euler equation one can find the equation for individual consumption,

$$C_t^s = (1 - \beta\vartheta) \left[A_t^s + H_t^s \right]. \tag{23}$$

This equation relates individual consumption to aggregate wealth, driven by financial and human wealth. As in Blanchard (1985), aggregate consumption is a linear function of total aggregate wealth. The household therefore consumes only a share of her financial wealth. This share is driven by the discount factor and the probability of surviving. We will later on come back to a more detailed discussion of this equation.

3.3.2 Firms

As we assumed that technology is constant returns to scale, we can focus on the solution to the optimization program of only one price taking firm.

This firm faces the cost minimization problem, viz. to choose the optimal input factor combination $\{K_t, N_t\}$ to produce a given output level, Y_t, and given their respective perfectly competitive prices. This problem is analogous to maximizing profits, hence the firm solves

$$\max_{\{N_t,K_t\}_{t=0}^{\infty}} \left\{ Y_t - W_t N_t - R_t^k K_t \right\}, \tag{24}$$

subject to the production frontier, eq. (7).

The solution to this sorting problem is an optimal capital-to-labor ratio,

$$\frac{K_t}{N_t} = \frac{\alpha}{1-\alpha}\frac{W_t}{R_t^K}, \tag{25}$$

i.e. a relation between payments and factors. Furthermore, we can find the standard expressions for the factor prices given by

$$W_t = \frac{(1-\alpha)\,Y_t}{N_t}, R_t^K = \frac{\alpha Y_t}{K_t}. \tag{26}$$

3.3.3 Aggregation

The aggregate value, X_t, of any individual variable, X_t^s, is obtained according to

$$X_t = (1-\vartheta)\sum_{s=0}^{\infty} \vartheta^s X_t^s. \tag{27}$$

Here, s refers to the generation born at period $t-s$. Then, aggregation of equations (22) and (23) over the generations alive at time t gives

$$\begin{aligned} A_{t+1} &= R_t\left[A_t - C_t + h_t\right], & (28)\\ C_t &= (1-\beta\vartheta)\left[A_t + H_t\right]. & (29) \end{aligned}$$

Using those two equations, one can derive an expression for aggregate consumption

$$C_t = \mathbb{E}_t \left\{ \frac{1}{R_t} \left[\frac{\psi}{1-\psi}(1-\vartheta)A_{t+1} + \frac{\vartheta}{1-\psi}C_{t+1} \right] \right\}, \tag{30}$$

where $\psi = (1 - \beta\vartheta)$. Notice, that as in the Blanchard (1985) model, labor income is equally distributed across agents, which simplifies the wealth distribution since all agents have the same human wealth and ensures that we can solve the aggregation problem. This assumption implies that all agents have positive labor supply and the same productivity.

As we have seen in the derivation of the equation for individual consumption, the households' consumption decision is driven by three forces. First, as usual the interest rate impacts the households' intertemporal decision. Second, the expectation of future consumption weighted by the probability of surviving, also reflects the consumption smoothing incentive, which is the standard implication of the permanent income hypothesis. Third, and driven by the perpetual-youth structure of our model, financial wealth drives the consumption decision. The higher the probability of surviving, the smaller consumption will be, as the permanent income hypothesis implies that households will smooth consumption. It is also straightforward that in the Ricardian benchmark case, $\vartheta = 1$, only the standard elements, the interest rate and future consumption, will determine present consumption. However, if we assume that $\vartheta < 1$, the path of consumption is also driven by the dynamics of financial wealth. This idea goes back to the seminal contribution from Barro (1974), showing that under certain conditions, government bonds are net wealth for households. Note that financial wealth in our model is also driven by interest payments on capital.

3.3.4 Equilibrium and Calibration

A competitive equilibrium in our model is defined as follows.

Definition

A competitive equilibrium for given initial conditions, the stochastic process $\{Z_t\}$ and a set of prices $\left\{R_t, q_t, R_t^K, W_t\right\}$, is a tuple of processes for $\{C_t, A_t, I_t, K_t, N_t, Y_t, B_t, G_t, \tau_t\}$ such that

1. Household optimality

Given $\left\{W_t, R_t, R_t^K\right\}$, the processes for $\{C_t^s, A_t^s, I_t^s, N_t^s, K_t^s\}$ solve the optimization problem for any individual agent out of generation s, maximizing (4) subject to (14) and the transversality condition (16) holds.

2. Aggregation

Individual variables are transformed into aggregate variables according to (27).

3. Profit maximization

The process for $\{K_t, N_t\}$ solve the optimization problem, maximizing (24) subject to (7). Processes for W_t and R_t^K follow (26).

4. Fiscal policy

The processes for $\{B_t, G_t, \tau_t\}$ are determined by (13) and (12), while the government budget constraint, (11), holds with equality.

5. Market clearing

In equilibrium, factor and goods market clear and any feasible allocations are those satisfying

$$Y_t \geq C_t + I_t + G_t. \tag{31}$$

Then, the set of equations forming the rational expectation equilibrium is log-linearized around the non-stochastic steady state and solved by applying the Sims (2002) algorithm.

The calibration of the model is on a quarterly basis for the United States and parameter values are set according to stylized facts and the relevant literature.

We set the discount factor to $\beta = 0.998$. The probability of death, $1 - \vartheta$, is set to 0.015 as in Leith and Wren-Lewis (2000). We will provide a robustness check of this crucial parameter and discuss its role for business cycle fluctuations. According to the estimations from Leeper et al. (2010a), we set $\varphi = 2$, which implies a Frisch labor supply elasticity of 0.5. Then, we set the elasticity of output to capital, α, to 0.3 which implies a labor share of 70 percent. The capital depreciation rate is set to 0.025, which is equal to a 10 percent annual depreciation rate. Tobin's q in steady state is set to unity. Steady state government consumption is set to 0.2 to match postwar U.S. data as shown in Baxter and King (1993).

The level of government debt in steady state, B, is set to 0.3396 as in Leeper et al. (2010). This value is choosen because it coincides with the share of federal debt held by private domestic investors in the United States. Therefore, we ensure not to overestimate the effectiveness of our new channel, by assuming that all government bonds are held by households.

Then, steady state taxes are given by $\tau = G - \left[\frac{\beta-1}{\beta}\right] B$. The steady state capital rental rate follows $\bar{R}^k = \frac{1}{\beta} - (1-\delta)$ and steady state aggregate technology, $\bar{Z}$, is set to unity. The autocorrelation of the technology shock is set to 0.9 and its variance is 0.0049, which matches the empirically observed volatility of U.S. GDP of 1.62 percent. Then, the steady state values for output, consumption, hours, and capital are given by the solution to the following linear system

$$\begin{aligned} \bar{Y} - \bar{C} - \bar{I} - \bar{G} &= 0, \qquad (32) \\ \bar{Y} - \bar{K}^{\alpha}\bar{N}^{1-\alpha} &= 0, \\ \bar{R}^K - \alpha\frac{\bar{Y}}{\bar{K}} &= 0, \\ \bar{N}^{1+\varphi} - (1-\alpha)\frac{\bar{Y}}{\bar{C}} &= 0. \end{aligned}$$

Finally, we need to calibrate the four parameters governing the fiscal rules. To do so, we estimate a SVAR adding the time series for government spending and tax revenues. Then, table 1 presents the point estimates for the parameters obtained from the SVAR estimation.

Table 1: SVAR point estimates for the fiscal rule parameters.

Parameter	Estimate	S.E.
τ_B	0.0014	0.0182
τ_Y	0.2077	0.0572
γ_B	0.0255	0.0060
γ_Y	0.0077	0.0189

We find that taxes as well as spending react positively to changes in output and debt. Spending reacts stronger to changes in debt than taxes do (0.0255 vs. 0.0014). On the flipside, taxes react much stronger to variations in output (0.2077 vs. 0.0077). However, we find that the response of taxes to debt as well as the response of spending to output is insignificant. Therefore, taxes mainly respond to output changes, while government spending reacts mainly to changes in debt.

Furthermore, the parameter values for the tax rule are at the lower bound of existing results by Leeper et al. (2010a, 2010b) ranging from -0.023 to 0.51 for the response of taxes to changes in debt, and 0.24 to 2.1 for the responsiveness of taxes to variations in output. However, the results for the government spending rule imply countercyclical movements. Here, the values range from -0.031 to -0.022 for the response of spending to changes in debt, and from -0.084 to -0.0064 for variations in output. Overall, we find that the responsiveness of taxes and spending is at the lower bound of the existing results obtained by applying Bayesian methods.

At the end of this section, we need to explain the way we calibrate the counterfactual, namely the countercyclical debt scenario. We multiply each value in the two fiscal rules by -1 to generate a countercyclical relationship between output and debt. Notice that our model is linear around its steady state. Therefore, the absolute size of fiscal policy effect is identical across regimes and we hence generate symmetric effects of pro- and countercyclical debt. Therefore, we exclude the possibility of creating results that are only driven by putting different (absolute) weights on the components in the fiscal rules.

4 Discussion

In the following, we want to discuss the response of our model to a mean-reverting, one percent favorable technology shock for two different calibrations of fiscal policy. In one case, the fiscal rules are calibrated such that debt moves procyclical, while in the other case debt moves countercyclical. The response of our model economy for those two cases is presented in Figure 2. Assume that our economy is hit by a positive, stationary technology shock. This shock will increase output and - as we have learned from our empirical analysis - debt will positively co-move with output. As debt increases, households feel richer, because debt is net wealth in the perpetual youth model. Consistently, this wealth effect affects the households' consumption-leisure decision and the labor supply schedule is shifted inwards, such that agents supply less labor compared to the countercyclical case. On the flipside, we observe that households consume less if debt moves procyclical over the cycle. Coherently, we see that output deviations are smaller and less persistent in response to the shock, which implies jointly with the behavior of households, that investment activity is lower in the procyclical case. This spills over to a smaller build up of the capital stock and a less persistent adjustment process. Intuitively, this creates further repercussions for household's wealth since financial wealth is also driven by the value of the capital stock.

We can draw the conclusion that fiscal policy affects the size of the wealth effect steaming from the change in debt, namely by putting different weights on their two goals defined in the fiscal rules.

Our stabilizing result can nicely be inferred from Table 2. Here, we present the relative standard deviation of key variables for the two fiscal policies considered as well as the difference, Δ, in percent.

As we have seen before, the economy with procyclical debt is significantly less volatile. We

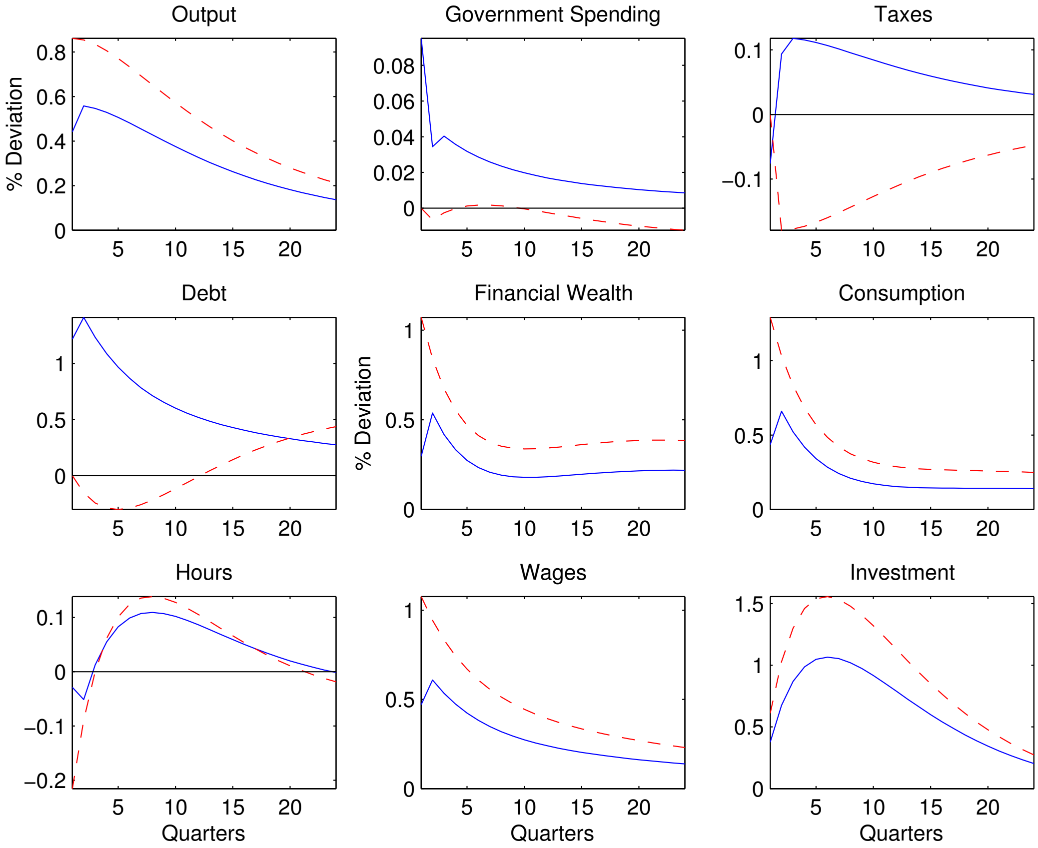

Figure 2: Model response to positive technology shock for counter- and procyclical debt. Horizontal axes measure quarters, vertical axes measure deviations from steady state. Blue, solid line is procyclical policy and red, dashed is countercyclical policy.

Table 2: Relative standard deviation for the two fiscal policies. Rstd is relative standard deviation with respect to output. Data values are taken from King and Rebelo (2000). Values for debt, spending, and taxes are based on own computations.

	Data	Procyclical	Countercyclical	Δ
$std(Y)$	1.81	0.75	1.17	-0.36
$Rstd(C)$	0.74	0.77	0.94	-0.18
$Rstd(N)$	0.99	0.21	0.21	0
$Rstd(I)$	2.93	2.05	1.91	0.07
$Rstd(W)$	0.38	0.88	0.95	-0.07
$Rstd(G)$	0.07	0.08	0.03	2.67
$Rstd(T)$	0.12	0.21	0.21	0
$Rstd(B)$	2.80	2.01	1.06	1.90

find that the volatility of output is 0.75 compared to 1.17 in the countercyclical case. This implies a stabilizing effect of 36 percent for output. The main difference can be found in the standard deviation of consumption. Since in our perpetual-youth model if policy affects debt, debt will effect household's wealth which directly drives the consumption/labor decision. We find that the standard deviation of consumption in the procyclical case is 0.77, while it is 0.94 in the countercyclical case. Furthermore, the second important dimension is labor supply. We find that the relative volatility stays roughly constant at 0.21. However, the absolute standard deviation of hours is significantly reduced (0.0016 vs. 0.0025). Here, we can identify the dampening effect of the wealth effect steaming from the procyclicality of government debt. This is further supported by exercises with different utility functions. If we shut down the wealth effect in the model, we observe much higher standard deviations of consumption and labor supply.[8] This proves that the positive wealth effect from government debt significantly effects the household's optimal allocation decision and explains why countercyclical policy is destabilizing.

Consequently, wages are less volatile since output and labor supply now move less volatile over the cycle. Standard deviation of investment is larger in the procyclical regime with 2.05 versus 1.91

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[8] To be precise, we use log-log preferences and preferences suggested by Greenwood et al. (1988) that generate a small short-run wealth effect.

in the countercyclical one. Finally, we observe that government spending is almost three times as volatile in the procyclical calibration, 0.08, as in the countercyclical example, 0.03. However, the volatility of taxes stays put at 0.21. Finally, the difference in volatility for government debt is large. In the procyclical case we obtain a standard deviation of 2.01, while in the countercyclical case, we obtain a value of 1.06. Hence, debt is almost twice as volatile, if fiscal policy is procyclical.

5 Robustness

First, we want to provide a robustness check on the parameters in the fiscal rules. A central result relates to generating the counterfactual. While there should be no disagreement about the multiplication by -1, it is less clear that all parameters have to be changed. In fact, it is possible to generate countercyclical debt by multiplying less than all four parameters. However, the following holds: every combination of fiscal rule parameters multiplied by -1 that generate countercyclical debt, will generate larger second moments compared to the procyclical case. Hence, our results are robust to different ways to generate the counterfactual.

A related, though different, question is how the volatilities are effected by different values of the important fiscal rule parameters, γ_B and τ_Y. To answer this question we plot the relative standard deviation of consumption as a function of those two parameters (see Figure 3). We observe a sharp decline of relative volatility in the upper-right corner of the τ_Y-γ_B plane, which is the procyclical debt part of this figure. In detail, there is a sharp decline of volatility once γ_B turns positive and τ_Y is not too negative. We can conclude that the value of γ_B mainly drives the volatilities in this model.

At the end of this section, we want to stress the importance of the assumption on the probability, $1 - \vartheta$. For this purpose, Figure 4 plots the difference in the relative standard deviations of key macro variables between pro- and countercyclical debt as a function of the probability to decease

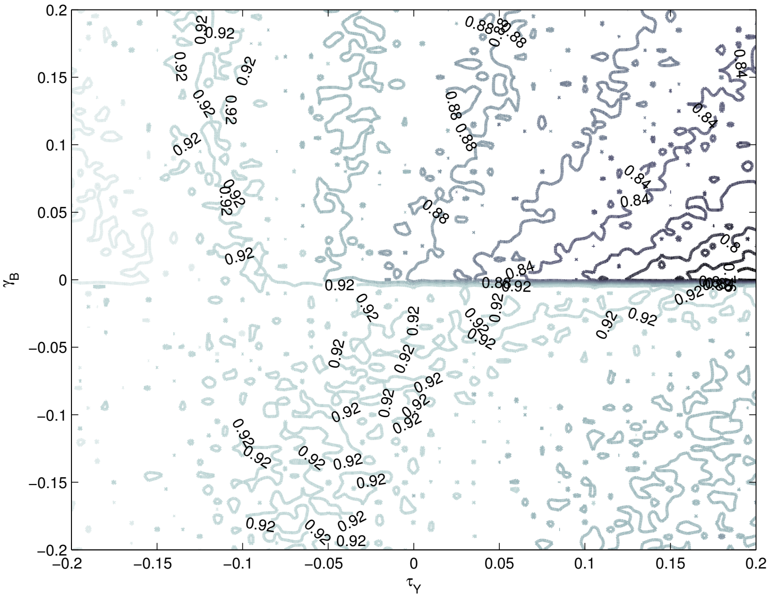

Figure 3: Contour plot of the relative standard deviation of consumption as a function of γ_B and τ_Y.

on the interval $[0.01, 0.02]$. To get an intuition for those values, consider that a death probability of 0.01 implies a lifetime of 100 periods, while a value of 0.2 implies a lifetime of 5 periods. Our baseline calibration of 0.015 results in an expected lifetime of roughly 70 periods. The figure shows that the difference between pro- and countercyclical debt for output, consumption, and hours stays negative over the interval. For investment, the opposite holds. Hence, we confirm that our result that procyclicality generates smaller volatilities of key variables holds independently from the value of the death probability. Further, we infer that a shorter lifetime (a larger value of $1 - \vartheta$) increases the difference between the two scenarios. This finding is in line with the intuition about the effects of fiscal policy for Non-Ricardian agents. The shorter the lifetime, the less likely it is that the agents have to face the higher financing burden and the more effective fiscal policy will be.

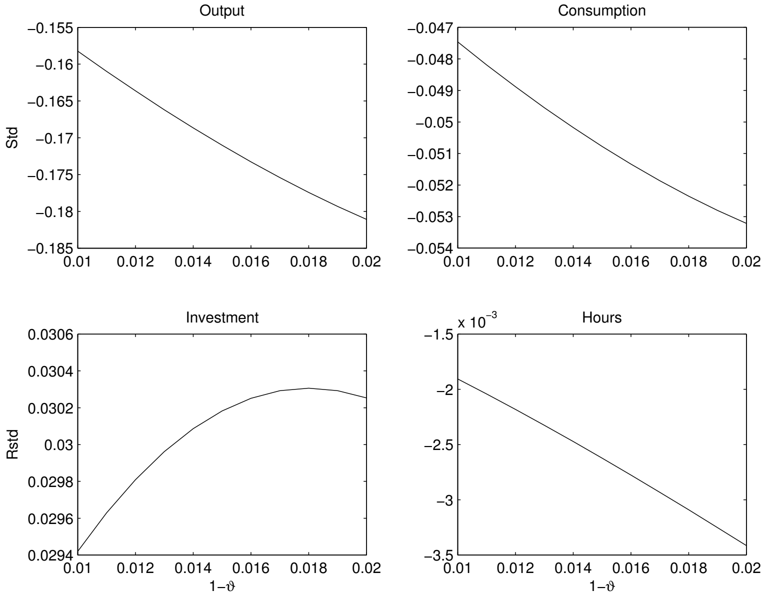

Figure 4: Difference in relative standard deviations w.r.t. output between pro- and countercyclical debt as a function of the probability $1-\vartheta$. For output, we plot the standard deviation.

6 Conclusion

The main contribution of this paper is theoretical. We show that government debt, as being a component of household's financial wealth, creates an additional wealth effect that has sizable effects on the business cycle. We interpret this channel as an additional automatic stabilizer of economic activity. Therefore, we present a new channel through which governments can influence cyclical fluctuations and achieve macroeconomic stability. The striking consequence is that classical (countercyclical) Keynesian fiscal policy destabilizes the business cycle in our framework.

In detail, this paper has two contributions. First, we systematically analyze the relation between output and government debt. For this purpose, we estimate a structural VAR identified by long-run restrictions to shed light on the underlying relationship between debt and output. Further, we estimate the parameters in fiscal rules describing the dynamics of spending and taxes. We find that debt is procyclical in output over the U.S. business cycle. Further, government spending is procyclical, while tax revenues are countercyclical.

Second, we build a Real Business Cycle model of the U.S. economy with Non-Ricardian agents. By implementing fiscal rules with endogenous feedback to output and debt, we are able to generate pro- and countercyclical fiscal policy. Further, fiscal rules allow us to write debt as a function of output, hence, creating an automatic stabilization role for debt. With those instruments, we show that standard deviations of key macroeconomic variables are significantly higher, if debt is countercyclical.

The intuition is an additional wealth effect that affects economic activity. The mechanism works as follows. In the perpetual-youth model, ceteris paribus, government debt is wealth from the household's perspective, because they are likely to not being affected by the higher tax burden of expansionary fiscal policy in the future. Higher productivity will increase output and - in the case of procyclical debt - debt will increase. This increase will lead to a rise in financial wealth of households. This additional wealth effect, which is not present in standard business cycle models, shifts the labor supply schedule inwards and agents supply less labor and consume more.

The implications for public policy are potentially severe and provocative. We have shown that in our framework the preferable policy instrument for business cycle stabilization is not the canonical, countercyclical Keynesian-type policy but, instead, procyclical policy. Further, fiscal policy can affect the size of the additional wealth effect steaming from the change in debt, namely by putting different weights on their two goals.

Finally, let us stress two limiting factors that should motivate future research. First, the interactions between fiscal and monetary policy rules should be analyzed to discuss the role of monetary policy. Besides implications for business cycle fluctuations, the channel might add to the discussion of fiscal determinations of the price level. We have seen that the discussed channel works for a all shocks that affect output. Hence, the combination of fiscal rules and Non-Ricardian agents allows fiscal policy to be of relevance for price level determination even for non-fiscal disturbances as stressed by the fiscal theory of the price level.

Lastly, a richer set of policy instruments, e.g. distortionary taxes and transfer payments, should be considered to allow for more detailed recommendations.

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