

# An RBC model with non-Ricardian households: lessons for Bulgaria (1999–2018)

Aleksandar Vasilev

*University of Lincoln - Brayford Campus, Lincoln, UK*

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## Abstract

**Purpose** – The authors introduce non-Ricardian (“hand-to-mouth”) myopic agents into an otherwise standard real-business-cycle (RBC) setup augmented with a detailed government sector. The authors investigate the quantitative importance of the presence of nonoptimizing households for cyclical fluctuations in Bulgaria.

**Design/methodology/approach** – The authors calibrate the RBC model to Bulgarian data for the period following the introduction of the currency board arrangement (1999–2018).

**Findings** – The authors find that the inclusion of such non-Ricardian households improves model performance along several dimensions and generally provides a better match vis-a-vis data, as compared to the standard model populated with Ricardian agents only.

**Originality/value** – This is a novel finding in the macroeconomic studies on Bulgaria using modern quantitative methods.

**Keywords** Business cycles, Non-Ricardian households, Hand-to-mouth, Myopic behavior, Bulgaria

**Paper type** Research paper

## 1. Introduction and motivation

One of the postulates of the real-business-cycle (RBC) theory is that household are rational, forward-looking individuals who make dynamically optimal decisions in the face of uncertainty. More specifically, they make consumption and leisure decisions based on an intertemporal criterion, and those allocations are not necessarily following their period income. By choosing their consumption path in an optimal manner, households also choose optimally how to split their current income between consumption and saving. In the standard RBC model, saving takes place in the form of investment in capital accumulation, and the possession of more physical capital generates a higher income in the future. In other words, physical capital is the vehicle in the model that allows households to transfer wealth over time [1].

An important implicit assumption made in the standard model is that capital markets are efficient, and households can freely save or borrow to smooth their consumption. Often such households are referred to as “Ricardian” as for them the so called “Ricardian equivalence” holds [2]. Alternatively, a one-time transfer is unlikely to significantly change (if at all) their current consumption. However, a major result documented in the empirical literature is the so called “excess sensitivity” of consumption relative to current income. In other words, current consumption seems to respond too much to current income. This comes in stark contrast with the permanent-income/life-cycle hypothesis, which argues that current consumption should follow permanent/life-time income and ignore changes in transitory (current) income, while

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trying to smooth consumption along their lifespan. These observed deviations from intertemporal optimization, which the standard RBC model is founded in, are puzzling. Still, those shortcoming of the benchmark setup can be rationalized with the incorporation of liquidity constraints, whose existence is a matter of fact.

We take the issues above seriously, and address them within a general-equilibrium context. We introduce non-Ricardian (“hand-to-mouth”) myopic agents, whose consumption will follow their current income due to their inability to borrow and smooth consumption intertemporally. Those nonoptimizing agents will populate the model economy and will cohabit with the forward-looking (Ricardian) agents, who will base their decision on the discounted future flow of income. Only Ricardian households are allowed to save and invest in physical capital, which is not possible for the non-Ricardian individuals, as the latter might be poor, subject to liquidity constraints or other forms of financial imperfections, which excludes them from participating in the capital markets. Such issues are typical in developing countries. Those issues might have significant effects for fiscal policy issues, as shown in [Mankiw \(2000\)](#), especially in economies where the proportion of non-Ricardian households is sufficiently large. In this paper we choose Bulgaria as a testing case, as Bulgaria, despite being a member state of the European Union (EU), is still the poorest member of the union ([NSI, 2019](#)) [3].

We then include both types of households into an otherwise standard RBC setup augmented with a detailed government sector [4]. We calibrate the model to Bulgarian data for the period following the introduction of the currency board arrangement (1999–2018). We investigate the quantitative importance of the presence of nonoptimizing households for cyclical fluctuations in Bulgaria. We find that the inclusion of such nonoptimizing households improves model performance along several dimensions and provide a better match vis-a-vis data, as compared to the standard model with Ricardian agents only. Therefore, capital markets imperfections, or restricted access to credit for some of the households in the population may have important repercussions for fiscal policy issues and income inequality, and thus the inclusion of non-Ricardian agents is a must when investigating such questions in general-equilibrium setups.

The rest of the paper is organized as follows: [Section 2](#) describes the model framework and describes the decentralized competitive equilibrium system, [Section 3](#) discusses the calibration procedure and [Section 4](#) presents the steady-state model solution. [Section 5](#) proceeds with the out-of-steady-state dynamics of model variables, and compared the simulated second moments of theoretical variables against their empirical counterparts. [Section 6](#) concludes the paper.

## 2. Model description

There is an  $\omega$  mass of forward-looking (Ricardian) households, and a  $1 - \omega$  mass of hand-to-mouth (non-Ricardian) households. Both types of households derive utility out of consumption and leisure, but only the Ricardian type can save and invest in capital. The time available to households can be spent in productive use or as leisure. The government taxes consumption spending, levies a common proportional (“flat”) tax on income, in order to finance wasteful purchases of government consumption goods and government transfers. On the production side, there is a representative firm, which hires labor and capital to produce a homogenous final good, which could be used for consumption, investment or government purchases.

### 2.1 Households

**2.1.1 Ricardian households.** There is an  $\omega$  mass ( $0 < \omega < 1$ ) of forward-looking (Ricardian) households, denoted by  $i$ , who maximize their expected utility function

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t^i + \gamma \ln(1 - h_t^i) \right\} \quad (2.1)$$

where  $E_0$  denotes household  $i$ 's expectations as of period 0,  $c_t^i$  denotes household  $i$ 's private consumption in period  $t$ ,  $h_t^i$  are hours worked in period  $t$ ,  $0 < \beta < 1$  is the discount factor,  $0 < \gamma < 1$  is the relative weight that the household attaches to leisure [5].

Every Ricardian household starts with an initial stock of physical capital  $k_0^i = k_0 > 0$ , and has to decide how much to add to it in the form of new investment. The law of motion for physical capital is

$$k_{t+1}^i = i_t^i + (1 - \delta)k_t^i \quad (2.2)$$

and  $0 < \delta < 1$  is the depreciation rate. Next, the real interest rate is  $r_t$ , hence the before-tax capital income of the household in period  $t$  equals  $r_t k_t^i$ . In addition to capital income, the Ricardian household can generate labor income. Hours supplied to the representative firm are rewarded at the hourly wage rate of  $w_t$ , so pretax labor income equals  $w_t h_t^i$ . Lastly, the Ricardian households own the firm in the economy and has a legal claim on all the firm's profit,  $\pi_t^i$ .

Next, the household's problem can be now simplified to

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t^i + \gamma \ln(1 - h_t^i) \right\} \quad (2.3)$$

s.t.

$$(1 + \tau^c)c_t^i + k_{t+1}^i - (1 - \delta)k_t^i = (1 - \tau^y) \left[ r_t k_t^i + \pi_t^i + w_t h_t^i \right] + g_t^i \quad (2.4)$$

where  $\tau^c$  is the tax on consumption,  $\tau^y$  is the proportional income tax rate ( $0 < \tau^c, \tau^y < 1$ ) and  $g_t^i$  denotes government transfers [6]. The Ricardian household takes the tax rates  $\{\tau^c, \tau^y\}$ , government spending categories,  $\{g_t^c, g_t^i\}_{t=0}^{\infty}$ , profit  $\{\pi_t^i\}_{t=0}^{\infty}$ , prices  $\{w_t, r_t\}_{t=0}^{\infty}$  and chooses  $\{c_t^i, h_t^i, k_{t+1}^i\}_{t=0}^{\infty}$  to maximize its utility subject to the budget constraint [7].

The first-order optimality conditions as as follows:

$$c_t^i : \frac{1}{c_t^i} = \lambda_t(1 + \tau^c) \quad (2.5)$$

$$h_t^i : \frac{\gamma}{1 - h_t^i} = \lambda_t(1 - \tau^y)w_t \quad (2.6)$$

$$k_{t+1}^i : \lambda_t = \beta E_t \lambda_{t+1} [1 + [1 - \tau^y)r_{t+1} - \delta] \quad (2.7)$$

$$\text{TVC} : \lim_{t \rightarrow \infty} \beta^t \lambda_t k_{t+1}^i = 0 \quad (2.8)$$

where  $\lambda_t$  is the Lagrangean multiplier attached to household  $i$ 's budget constraint in period  $t$ . The interpretation of the first-order conditions above is as follows: the first one states that for each household, the marginal utility of consumption equals the marginal utility of wealth, corrected for the consumption tax rate. The second equation states that when choosing labor supply optimally, at the margin, each hour spent by the household working for the firm should balance the benefit from doing so in terms of additional income generates, and the cost measured in terms of lower utility of leisure. The third equation is the so-called "Euler condition," which describes how the household chooses to allocate physical capital over time. The last condition is called the "transversality condition" (TVC): it states that at the end of the horizon, the value of physical capital should be zero.

*2.1.2 Non-Ricardian households.* There is a unit measure of “hand-to-mouth” (non-Ricardian) households, denoted by  $j$ , who maximize the same expected utility function as the Ricardian agents:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t^j + \gamma \ln(1 - h_t^j) \right\} \quad (2.9)$$

where  $E_0$  denotes household  $j$ 's expectations as of period 0,  $c_t^j$  denotes household  $j$ 's private consumption in period  $t$ ,  $h_t^j$  are hours worked in period  $t$ .

In contrast to the Ricardian households, non-Ricardian agents are not able to save or borrow, due to some financial frictions such as liquidity constraints. The only source of income is labor and the government transfers, so their budget constraint is

$$(1 + \tau^c)c_t^j = (1 - \tau^y)w_t h_t^j + g_t^j \quad (2.10)$$

Note that the wage rate is the same for everyone, as labor services are assumed to be homogeneous. In addition, the dynamic optimization problem faced by non-Ricardian households is degenerate, and collapses to a sequence of static problems, and choices are made in an environment characterized by certainty.

In other words, non-Ricardians solve

$$\max \ln c_t^j + \gamma \ln(1 - h_t^j) \quad (2.11)$$

s.t

$$(1 + \tau^c)c_t^j = (1 - \tau^y)w_t h_t^j + g_t^j \quad (2.12)$$

The Ricardian household takes the tax rates  $\{\tau^c, \tau^y\}$ , government transfers,  $\{g_t^i\}_{t=0}^{\infty}$  and wages  $\{w_t\}_{t=0}^{\infty}$ , and chooses  $c_t^j, h_t^j, \forall t$  to maximize its period utility subject to the period budget constraint.

The first-order optimality conditions are as follows:

$$c_t^j : \frac{1}{c_t^j} = \lambda_t(1 + \tau^c) \quad (2.13)$$

$$h_t^j : \frac{\gamma}{1 - h_t^j} = \lambda_t(1 - \tau^y)w_t \quad (2.14)$$

The interpretations are identical to the Ricardian case. Note that the shadow price of wealth  $\lambda_t$  is the same for both types of households, as preferences are the same, and the marginal rate of substitution is also the same.

## 2.2 Firm problem

There is a representative firm in the economy, which produces a homogeneous product. The price of output is normalized to unity. The production technology is Cobb–Douglas and uses both physical capital,  $k_t^f$  and labor hours,  $h_t^f$ , to maximize static profit

$$\Pi_t = A_t (k_t^f)^\alpha (h_t^f)^{1-\alpha} - r_t k_t^f - w_t h_t^f, \quad (2.15)$$

where  $A_t$  denotes the level of technology in period  $t$ . Since the firm rents the capital from households, the problem of the firm is a sequence of static profit maximizing problems. In equilibrium, there are no profits, and each input is priced according to its marginal product, i.e.:

$$k_t : \alpha \frac{y_t}{k_t^f} = r_t, \quad (2.16)$$

$$h_t : (1 - \alpha) \frac{y_t}{h_t^f} = w_t. \quad (2.17)$$

In equilibrium, given that the inputs of production are paid their marginal products,  $\Pi_t = \pi_t^i = 0, \forall t$ .

### 2.3 Government

In the model setup, the government is levying taxes on labor and capital income, as well as consumption, in order to finance spending on wasteful government purchases and government transfers. The government budget constraint is as follows:

$$g_t^c + g_t^t = \tau^c [\omega c_t^i + (1 - \omega) c_t^j] + \tau^y [w_t h_t^f + r_t k_t^f] \quad (2.18)$$

Income tax rate and government consumption-to-output ratio would be chosen to match the average share in data, and consumption taxation is progressive. Finally, government transfers would be determined residually in each period so that the government budget is always balanced.

### 2.4 Market clearing

In addition to the optimality conditions from the households' and firm's problem, as presented in the previous subsections, and the government budget constraint above, we need to impose consistency among the different decisions. More specifically, this would require that in equilibrium (1) aggregate quantities equal the sum of individual allocations and (2) output, capital and labor markets all clear, or for all  $t$ :

$$\omega c_t + (1 - \omega) c_t^j = C_t \quad (2.19)$$

$$\omega k_t^i = k_t^f = K_t \quad (2.20)$$

$$\omega h_t^i = I_t \quad (2.21)$$

$$\omega h_t^j + (1 - \omega) h_t^f = h_t^f = H_t. \quad (2.22)$$

$$C_t + I_t + g_t^c = Y_t, \quad (2.23)$$

where capital letters denote aggregate allocations.

### 2.5 Dynamic competitive equilibrium (DCE)

For a given process followed by technology  $\{A_t\}_{t=0}^{\infty}$ , tax rates  $\{\tau^c, \tau^y\}$  and initial capital stock  $\{k_0^i\}$ , the decentralized dynamic competitive equilibrium is a list of aggregate allocations  $\{C_t, I_t, K_t, H_t, Y_t\}_{t=0}^{\infty}$ , a list of sequences  $\{c_t^i, i_t^i, k_t^i, h_t^i\}_{t=0}^{\infty}$  for the Ricardian households, a list of sequences  $\{c_t^j, h_t^j\}_{t=0}^{\infty}$  for the non-Ricardian households, a list of sequences  $\{k_t^f, h_t^f\}_{t=0}^{\infty}$  for the firm, a sequence of government purchases and transfers  $\{g_t^c, g_t^t\}_{t=0}^{\infty}$ , and input prices  $\{w_t, r_t\}_{t=0}^{\infty}$  such that (1) the Ricardian and non-Ricardian households maximize their utility function subject to their budget constraint; (2) the representative firm maximizes profit; (3) government budget is balanced in each period; (4) all markets clear.

### 3. Data and model calibration

To characterize business cycle fluctuations in Bulgaria, we will focus on the period following the introduction of the currency board (1999–2018). Quarterly data on output, consumption and investment were collected from [National Statistical Institute \(2019\)](#), while the real interest rate is taken from Bulgarian [National Bank Statistical Database \(2019\)](#). The calibration strategy described in this section follows a long-established tradition in modern macroeconomics: first, as in [Vasilev \(2016a, b\)](#), the discount factor,  $\beta = 0.982$ , is set to match the steady-state capital-to-output ratio in Bulgaria,  $k/y = 13.964$ , in the steady-state Euler equation. The labor share parameter,  $1 - \alpha = 0.571$ , is obtained as in [Vasilev \(2017d\)](#), and equals the average value of labor income in aggregate output over the period 1999–2016. This value is slightly higher as compared to other studies on developed economies, due to the overaccumulation of physical capital, which was part of the ideology of the totalitarian regime, which was in place until 1989. Next, the average labor and capital income tax rate was set to  $\tau^y = 0.1$ . This is the average effective tax rate on income between 1999 and 2007, when Bulgaria used progressive income taxation, and equal to the proportional income tax rate introduced as of 2008. Similarly, the average tax rate on consumption is set to its value over the period,  $\tau^c = 0.2$ .

Next, the relative weight attached to the utility out of leisure in the household's utility function,  $\gamma$ , is calibrated to match that in steady-state consumers would supply one-third of their time endowment to working. This is in line with the estimates for Bulgaria ([Vasilev, 2017a](#)) as well over the period studied. Next, the depreciation rate of physical capital in Bulgaria,  $\delta = 0.013$ , was taken from [Vasilev \(2016a, b\)](#). It was estimated as the average quarterly depreciation rate over the period 1999–2014.

Parameter  $\omega$  is a bit tricky to calibrate: [Vasilev \(2015c\)](#) shows that for the period right after the banking and financial crisis in Bulgaria (1997–2005), which wiped most of the savings of the population, essentially everyone was liquidity constrained, or  $\omega = 0$ . Since then, however, the economy stabilized and started growing, so in our computational experiment, we will set  $\omega = 0.6$ , giving the Ricardian agents a small majority [8]. Finally, the process followed by TFP is estimated from the detrended series by running an AR(1) regression and saving the residuals. [Table 1](#) below summarizes the values of all model parameters used in the paper.

### 4. Steady-state

Once the values of model parameters were obtained, the steady-state equilibrium system solved, the “big ratios” can be compared to their averages in Bulgarian data. The results are reported in [Table 2](#) below. The steady-state level of output was normalized to unity (hence the level of technology  $A$  differs from one, which is usually the normalization done in other studies), which greatly simplified the computations. Next, the model matches consumption-to-output and government purchases ratios by construction; the investment ratios are also

Parameter	Value	Description	Method
$\beta$	0.982	Discount factor	Calibrated
$\alpha$	0.429	Capital share	Data average
$1 - \alpha$	0.571	Labor share	Calibrated
$\gamma$	0.873	Relative weight attached to leisure	Calibrated
$\delta$	0.013	Depreciation rate on physical capital	Data average
$\tau^y$	0.100	Average tax rate on income	Data average
$\tau^c$	0.200	VAT/consumption tax rate	Data average
$\omega$	0.600	Proportion of Ricardian households	Set
$\rho_a$	0.701	AR(1) persistence coefficient, TFP process	Estimated
$\sigma_a$	0.044	st. error, TFP process	Estimated

**Table 1.**  
Model parameters

closely approximated, despite the closed-economy assumption and the absence of foreign trade sector. The shares of income are also identical to those in data, which is an artifact of the assumptions imposed on functional form of the aggregate production function. The after-tax return, where  $\bar{r} = (1 - \tau^y)r - \delta$  is also relatively well-captured by the model. Lastly, given the absence of debt, and the fact that transfers were chosen residually to balance the government budget constraint, the result along this dimension is understandably not so close to the average ratio in data.

## 5. Out of steady-state model dynamics

Since the model does not have an analytical solution for the equilibrium behavior of variables outside their steady-state values, we need to solve the model numerically. This is done by log-linearizing the original equilibrium (nonlinear) system of equations around the steady-state. This transformation produces a first-order system of stochastic difference equations. First, we study the dynamic behavior of model variables to an isolated shock to the total factor productivity process, and then we fully simulate the model to compare how the second moments of the model perform when compared against their empirical counterparts.

### 5.1 Impulse response analysis

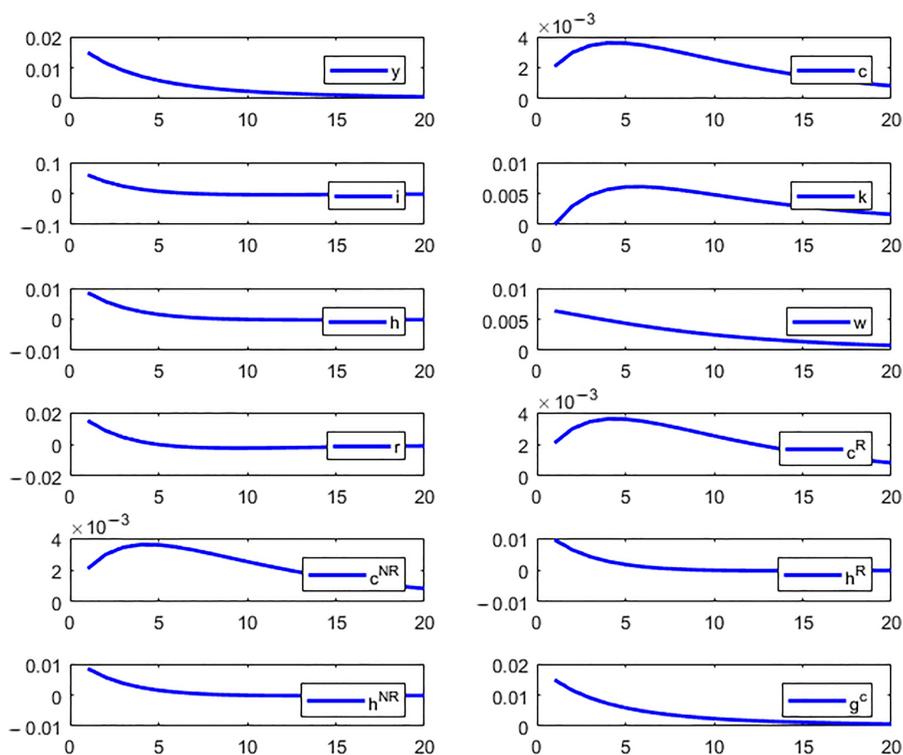
This subsection documents the impulse responses of model variables to a 1% surprise innovation to technology. The impulse response functions are presented in [Figure 1](#) on the next page. As a result of the one-time unexpected positive shock to total factor productivity, output increases upon impact. This expands the availability of resources in the economy, so used of output – consumption, investment and government consumption also increase contemporaneously.

At the same time, the increase in productivity increases the after-tax return on the two factors of production, labor and capital. The households then respond to the incentives contained in prices: the Ricardian households start accumulating capital, and supply more hours worked, while non-Ricardian agents only increase their labor supply. In turn, the increase in capital input feeds back in output through the production function and that further adds to the positive effect of the technology shock. In the labor market, the wage rate increases, and both types of households increase their hours worked. In turn, the increase in total hours further increases output, again indirectly.

Over time, as capital is being accumulated, its after-tax marginal product starts to decrease, which lowers the households' incentives to save. As a result, physical capital stock eventually returns to its steady-state, and exhibits a hump-shaped dynamics over its transition path. The rest of the model variables return to their old steady-states in a monotone fashion as the effect of the one-time surprise innovation in technology dies out. Overall, at aggregate level, the behavior of the economy is identical to that of the standard model, even though only a fraction of households are allowed to save and invest.

Variable	Description	Data	Model
$y$	Steady-state output	N/A	1.000
$c/y$	Consumption-to-output ratio	0.648	0.674
$i/y$	Investment-to-output ratio	0.201	0.175
$k/y$	Capital-to-output ratio	13.96	13.96
$g^c/y$	Government consumption-to-output ratio	0.151	0.151
$wh/y$	Labor income-to-output ratio	0.571	0.571
$rk/y$	Capital income-to-output ratio	0.429	0.429
$h$	Share of time spent working	0.333	0.333
$\bar{r}$	After-tax net return on capital	0.014	0.016

**Table 2.**  
Data averages and  
long-run solution



**Figure 1.**  
Impulse responses to a  
1% surprise  
innovation in  
technology

### 5.2 Simulation and moment-matching

As in [Vasilev \(2017b\)](#), we will now simulate the model 10,000 times for the length of the data horizon. Both empirical and model simulated data are detrended using the [Hodrick-Prescott \(1980\)](#) filter. [Table 3](#) on the next page summarizes the second moments of data (relative volatilities to output, and contemporaneous correlations with output) versus the same moments computed from the model-simulated data at quarterly frequency. The “Model” is

	Data	Model	Benchmark RBC
$\sigma_y$	0.05	0.05	0.05
$\sigma_c/\sigma_y$	0.55	0.56	0.82
$\sigma_i/\sigma_y$	1.77	2.13	2.35
$\sigma_g/\sigma_y$	1.21	1.00	1.00
$\sigma_h/\sigma_y$	0.63	0.35	0.28
$\sigma_w/\sigma_y$	0.83	0.69	0.86
$\sigma_y/h/\sigma_y$	0.86	0.69	0.86
$\text{corr}(c, y)$	0.85	0.91	0.90
$\text{corr}(i, y)$	0.61	0.79	0.83
$\text{corr}(g, y)$	0.31	1.00	1.00
$\text{corr}(h, y)$	0.49	0.91	0.59
$\text{corr}(w, y)$	-0.01	0.97	0.96

**Table 3.**  
Business cycle  
moments

the case with both Ricardian and non-Ricardian households, while the “Benchmark RBC” is the standard setup with Ricardian agents only. In addition, to minimize the sample error, the simulated moments are averaged out over the computer-generated draws. As in [Vasilev \(2016a, b, 2017b, c\)](#), both models match quite well the absolute volatility of output. By construction, government consumption in both models varies as much as output. Furthermore, both models are qualitatively consistent with the stylized fact that consumption generally varies less than output, while investment is more volatile than output. However, the predicted consumption in the setup with non-Ricardian households is almost perfectly matched; investment volatilities is lower and closer to that in data, as compared to the benchmark case.

With respect to the labor market variables, the variability of employment predicted by both models is lower than that in data, but a bit closer to data in the model with non-Ricardian households. Next, the variability of wages in the standard model is very close to that in data, and significantly lower in the model with non-Ricardian households. This is yet another confirmation that the perfectly competitive assumption for the wage rate, e.g. [Vasilev \(2009\)](#), as well as the benchmark calibration here, does not describe very well the dynamics of labor market variables. Next, in terms of contemporaneous correlations, both model systematically overpredicts the pro-cyclicality of the main aggregate variables – consumption, investment and government consumption. This, however, is a common limitation of this class of models. Along the labor market dimension, the contemporaneous correlation of employment with output in data is moderate, which is also what the standard model generates, while the model with non-Ricardian predicts a much higher one [9]. With respect to wages, both model predict strong pro-cyclicality, while wages in data are acyclical. This shortcoming is well-known in the literature and an artifact of the wage being equal to the labor productivity in the model.

In the next subsection, as in [Vasilev \(2016a, b\)](#), we investigate the dynamic correlation between labor market variables at different leads and lags, thus evaluating how well the model matches the phase dynamics among variables. In addition, the autocorrelation functions (ACFs) of empirical data, obtained from an unrestricted VAR(1) are put under scrutiny and compared and contrasted to the simulated counterparts generated from the model.

### 5.3 Auto- and cross-correlation

This subsection discusses the auto-(ACFs) and cross-correlation functions (CCFs) of the major model variables, presented in [Table 4](#) below [10]. For the sake of economizing space, we present only the results for the model with non-Ricardian households.

As seen from [Table 4](#) above, the model compares relatively well vis-a-vis data. Empirical ACFs for output and investment are slightly outside the confidence band predicted by the model, while the ACFs for total factor productivity and household consumption are well-approximated by the model. The persistence of labor market variables are also relatively well-described by the model dynamics. Overall, the model with non-Ricardian households generates too much persistence in output and both employment and unemployment, and is subject to the criticism in [Nelson and Plosser \(1992\)](#); [Cogley and Nason \(1995\)](#) and [Rotemberg and Woodford \(1996b\)](#), who argue that the RBC class of models do not have a strong internal propagation mechanism besides the strong persistence in the TFP process. In those models, e.g. [Vasilev \(2009\)](#), and in the current one, labor market is modeled in the Walrasian market-clearing spirit, and output and unemployment persistence is low. Next, as seen from [Table 5](#) below, over the business cycle, in data labor productivity leads employment. The model, however, cannot account for this fact. As in the standard RBC model a technology shock can be regarded as a factor shifting the labor demand curve, while holding the labor supply curve constant. Therefore, the effect between employment

Method	Statistic	$k$					RBC model with non- Ricardian households
		0	1	2	3		
Data	$\text{corr}(u_t, u_{t-k})$	1.000	0.765	0.552	0.553		
Model	$\text{corr}(u_t, u_{t-k})$	1.000	0.955	0.900	0.835		
	(s.e.)	(0.000)	(0.028)	(0.054)	(0.078)		
Data	$\text{corr}(n_t, n_{t-k})$	1.000	0.484	0.009	0.352		
Model	$\text{corr}(n_t, n_{t-k})$	1.000	0.955	0.900	0.835		
	(s.e.)	(0.000)	(0.028)	(0.054)	(0.078)		
Data	$\text{corr}(y_t, y_{t-k})$	1.000	0.810	0.663	0.479		
Model	$\text{corr}(y_t, y_{t-k})$	1.000	0.958	0.907	0.848		
	(s.e.)	(0.000)	(0.026)	(0.050)	(0.073)		
Data	$\text{corr}(a_t, a_{t-k})$	1.000	0.702	0.449	0.277		
Model	$\text{corr}(a_t, a_{t-k})$	1.000	0.956	0.902	0.840		
	(s.e.)	(0.000)	(0.027)	(0.052)	(0.077)		
Data	$\text{corr}(c_t, c_{t-k})$	1.000	0.971	0.952	0.913		
Model	$\text{corr}(c_t, c_{t-k})$	1.000	0.959	0.910	0.855		
	(s.e.)	(0.000)	(0.025)	(0.048)	(0.071)		
Data	$\text{corr}(i_t, i_{t-k})$	1.000	0.810	0.722	0.594		
Model	$\text{corr}(i_t, i_{t-k})$	1.000	0.953	0.895	0.826		
	(s.e.)	(0.000)	(0.029)	(0.055)	(0.080)		
Data	$\text{corr}(w_t, w_{t-k})$	1.000	0.760	0.783	0.554		
Model	$\text{corr}(w_t, w_{t-k})$	1.000	0.959	0.909	0.853		
	(s.e.)	(0.000)	(0.025)	(0.048)	(0.071)		

**Table 4.**  
Autocorrelations for  
Bulgarian data and the  
model economy

Method	Statistic	$k$							Dynamic correlations for Bulgarian data and the model economy
		-3	-2	-1	0	1	2	3	
Data	$\text{corr}(h_t, (y/h)_{t-k})$	-0.342	-0.363	-0.187	-0.144	0.475	0.470	0.346	
Model	$\text{corr}(h_t, (y/h)_{t-k})$	0.030	0.043	0.061	0.799	0.200	0.124	0.070	
	(s.e.)	(0.326)	(0.283)	(0.233)	(0.122)	(0.228)	(0.269)	(0.308)	
Data	$\text{corr}(h_t, w_{t-k})$	0.355	0.452	0.447	0.328	-0.040	-0.390	-0.57	
Model	$\text{corr}(h_t, w_{t-k})$	0.030	0.043	0.061	0.799	0.200	0.124	0.070	
	(s.e.)	(0.326)	(0.283)	(0.233)	(0.122)	(0.228)	(0.269)	(0.308)	

**Table 5.**  
Dynamic correlations  
for Bulgarian data and  
the model economy

and labor productivity is only a contemporaneous one, despite the presence of non-Ricardian agents in the economy.

## 6. Conclusions

We introduce non-Ricardian (“hand-to-mouth”) myopic agents into an otherwise standard real-business-cycle setup augmented with a detailed government sector. We calibrate the model to Bulgarian data for the period following the introduction of the currency board arrangement (1999–2018). We investigate the quantitative importance of the presence of nonoptimizing households for cyclical fluctuations in Bulgaria. We find that the inclusion of such nonoptimizing households improves model performance along several dimensions and provide a better match vis-a-vis data, as compared to the standard model with Ricardian agents only. Therefore, capital markets imperfections, or restricted access to credit for some of the households in the population may have important repercussions for fiscal policy issues and income inequality, and thus the inclusion of non-Ricardian agents is a must when investigating such questions in general-equilibrium setups.

## Notes

1. In the general case physical capital is also assumed to be “reversible,” or that investment can be negative, i.e. physical capital can be transformed into a consumption good, and eaten. Those are so-called “putty-putty” economies. There are “putty-clay” economies where capital is “irreversible”: once invested, it cannot be transformed back into consumption.
2. This means that households will foresee that a tax cut today translates into a tax increase in the future. If not, the government budget constraint will be violated. The amount of the tax cut will be then saved and invested to meet the increased household’s tax liability in the future.
3. Empirical studies on other countries, performed using both micro- and macroeconomic data, have also shown that a significant share of the population is subject to borrowing constraints, e.g. [Campbell and Mankiw \(1989\)](#), [Deaton \(1992\)](#), [Wolff \(2003\)](#), [Souleses \(1999\)](#) and [Johnson \*et al.\* \(2006\)](#), among many others.
4. Other studies that utilize Ricardian and non-Ricardian households, mostly to study fiscal policy issues, are [Coenen and Straub \(2005\)](#), [Gali \*et al.\* \(2007\)](#), [Iwata \(2009\)](#), among many others.
5. This utility function is equivalent to a specification with a separable term containing government consumption, e.g. [Baxter and King \(1993\)](#). Since in this paper we focus on the exogenous (observed) policies, and the household takes government spending as given, the presence of such a term is irrelevant. For the sake of brevity, we skip this term in the utility representation above.
6. Note that government transfers are not type-dependent.
7. Note that by choosing  $k_{t+1}^i$  the Ricardian household is implicitly setting investment  $i_t^i$  optimally.
8. [Coenen and Straub \(2005\)](#) estimate  $1 - \omega = 0.24$ . [Iwata \(2009\)](#) uses  $\omega = 0.7$  arguing that the non-Ricardian agents are the remaining ones, which are subject to liquidity constraints. [Gali \*et al.\* \(2007\)](#) use  $\omega = 0.5$  as a benchmark.
9. One way to address this limitation is to assume, as in [Torres \(2013\)](#), that non-Ricardian agents hold their hours worked fixed, which would decrease the volatility of aggregate hours by the share of non-Ricardian households in the population.
10. Following [Canova \(2007\)](#), this is used as a goodness-of-fit measure.

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### Further reading

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**Corresponding author**

Aleksandar Vasilev can be contacted at: [alvasilev@yahoo.com](mailto:alvasilev@yahoo.com)