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Indeterminacy with preferences featuring multiplicative habits in consumption: lessons from Bulgaria (1999-2016)

Aleksandar Vasilev*

Abstract

We introduce consumption habits into an exogenous growth model augmented with a detailed government sector, and calibrate the model to Bulgarian data for the period following the introduction of the currency board arrangement (1999-2016). We show that in contrast to the case without habits, *e.g.*, Vasilev (2009), when the economy features saddle-path stability, the habit motive alone leads to equilibrium indeterminacy in the model. When habits enter multiplicatively in the representative agent's utility function, the setup exhibits "sink" dynamics, and equilibrium paths are determined by "animal spirits." These results are in line with the findings in the literature, *e.g.*, Benhabib and Farmer (1994, 1996) and Farmer (1999), and have major implications for polcy-making and welfare.

Keywords: Equilibrium indeterminacy, animal spirits, multiplicative consumption habits, Bulgaria

JEL Classification Codes: E32, E22, E37

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1 Introduction and Motivation

In data, consumption generally varies less than output for most of the developed economies. This behavior is also observed in new EU member states: Private final consumption in Bulgaria varies twice less than output in Bulgaria in the period after the introduction of the currency board arrangement.[1] These stylized facts can be rationalized by rational individuals, who optimize their consumption level inter-temporally (over time). The standard Real-Business-Cycle model, however, when calibrated to Bulgarian data, *e.g.* Vasilev (2009), overpredicts consumption volatility, when only technology shocks are present in the model. Introducing taxation and government spending does not solve this puzzle. One reason for the failure of the model along the consumption dimension is that there could be some motive at play that generates extreme consumption smoothing, which - while quantitatively important - is not present in the standard setup.

One way to improve the model fit, as proposed in the literature, is to include habits in consumption as part of the preferences. As pointed out by Campbell and Cochrane (1999), habits are a fundamental concept in human psychology. Smets and Wouters (2003) also include habits in their large-scale macroeconomic model, and found that feature generated a better fit and improved the forecasting properties of the model.[2] More specifically, lagged consumption will be introduced into the household's utility function, and the household will not want its current consumption to deviate from the past. With this extension, the utility function is no longer time-separable, which increases consumption persistence. Such an adjustment cost in consumption may help the model quantitatively to decrease consumption volatility, as adjustment will be done via capital accumulation (saving) and investment. In addition, consumption habits could be thought of capturing deviations from the permanent income-life cycle hypothesis, which were also documented empirically for Bulgaria, *e.g.*, Vasilev (2015c). In Bulgaria, (some) households behave in a myopic way, with current con-

[1] A currency board arrangement is an extreme form of fixed exchange rate, where 1 Bulgarian lev (BGN) was fixed to 1 Deutsche Mark (DM), and with the introduction of the Euro, to the Euro, at the rate 1 Euro = 1.95582 BGN. The period after the introduction of the currency board arrangement in Bulgaria was chosen as that was a period of macroeconomic stability.

[2] Similarly, Buriel *at al.* (2010) include consumption habits in their model for the Spanish economy. For a review of the literature on habit formation, the interested reader is referred to Deaton (1992).

sumption tracking (showing "excess sensitivity" to) current income, instead of permanent one.

In the literature, two major classes of models with habits have been utilized, which differ in terms of the reference level of consumption with respect to which the habits stock is formed. In the class of models with "internal habits," the reference stock is formed from own past consumption levels, *e.g.*, Constantinides (1990), Fuhrer (2000), and Boldrin *et al.* (2001). In the model with "external habits," habits relate to the (economy-wide) average consumption, *e.g.*, Campbell and Cochrane (1999), Lettau and Uhlig (2000), and Turnovsky and Monteiro (2007). Overall, there is not much difference in term of model dynamics between the two approaches. Both modelling approaches of habit formation usually take a form in which utility is derived from the difference between current consumption level and the habit stock (usually weighted past consumption). The major problem with such an additive functional forms is that for plausible values of model parameters, marginal utility of current consumption could turn out negative, which makes no economic sense.

This led to the use of multiplicative form of habits, as in Abel (1990) and Carroll (2000), with an additional process followed by habits which causes the habits term to fall simultaneously with a decrease in consumption, when consumption "gets too close" to the stock of habits. That way of introducing habits preserves consumption to positive levels. As pointed in Carroll (2001), habits make consumption "sticky" as they pull current consumption towards its past level. Thus, by making consumption response sluggish, habit formation introduces endogenous persistence in model dynamics, and may generate interesting equilibrium dynamics in the setup. The focus in this paper is to examine the effect of multiplicative habits on the stability properties of equilibrium in the Bulgarian economy. Bulgaria was chosen as an EU country characterized by strong traditions and high degrees of conservatism. We show that in contrast to the case without habits, *e.g.*, Vasilev (2009), when the economy features saddle-path stability, the multiplicative habits in consumption alone generate equilibrium indeterminacy in the model.[3] When habits enter multiplicatively in the repre-

[3]Here we focus on infinite-horizon models. For indeterminacy with habits in overlapping-generations (OLG) setups, see Bossi and Gomis-Porqueras (2009).

sentative agent's utility function, the setup exhibits global stability ("sink" dynamics), and equilibrium paths are determined by "animal spirits."[4] These results are in line with the findings in the literature, *e.g.*, Benhabib and Farmer (1994, 1996) and Farmer (1999), and have major implications for policy-making and welfare.

The rest of the paper is organized as follows: Section 2 presents the model setup and defines the equilibrium system. Section 3 describes the data used and the calibration procedure. Section 4 characterizes the model economy's long-run behavior. Section 5 evaluates the model stability. Section 6 discusses the results, and Section 7 concludes.

2 Model Description

There is a representative households which derives utility out of consumption and leisure. The time available to households can be spent in productive use or as leisure. The government taxes consumption spending and levies a common tax on all 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 Household

There is a representative household, which maximizes its expected utility function, which features time-nonseparability in consumption with multiplicative habits, as in Carroll (2000):

$$\max_{\{c_t,h_t,k_{t+1}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{(c_t/z_t^{\phi})^{1-\sigma}}{1-\sigma} + \gamma \ln(1-h_t) \right\} \tag{2.1}$$

where E_0 denotes household's expectations as of period 0, c_t denotes household's private consumption in period t, z_t refers to the habits, $0 < \phi < 1$ measures the importance of habits, h_t 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, and σ is the curvature parameter of the utility of consumption.

[4] When habits enter additively, the model again features saddle-path stability.

As in Muellbauer (1988), Fuhrer (2000), and Carroll (2000), the habit stock will be assumed to follow an adaptive process of the form[5]

$$z_{t+1} = z_t + \theta(c_t - z_t), \tag{2.2}$$

where z_0 is taken as given by the household, and θ indexes the speed at which habits converge to consumption.[6]

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

$$k_{t+1} = i_t + (1 - \delta)k_t \tag{2.3}$$

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 $r_t k_t$. In addition to capital income, the household can generate labor income. Hours supplied to the representative firm are rewarded at the hourly wage rate of w_t, so pre-tax labor income equals $w_t h_t$. Lastly, the household owns the firm in the economy and has a legal claim on all the firm's profit, π_t.

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

$$\max_{\{c_t, h_t, k_{t+1}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{(c_t/z_t^{\phi})^{1-\sigma}}{1-\sigma} + \gamma \ln(1 - h_t) \right\} \tag{2.4}$$

s.t.

$$(1 + \tau^c)c_t + k_{t+1} - (1 - \delta)k_t = (1 - \tau^y)[w_t h_t + r_t k_t] + g_t^t + \pi_t, \tag{2.5}$$

$$z_t = z_{t-1} - \theta(c_{t-1} - z_{t-1}) \tag{2.6}$$

where τ^c is the tax on consumption, τ^y is the proportional income tax rate ($0 < \tau^c, \tau^y < 1$), levied on both labor and capital income, and g_t^t denotes government transfers. The household

[5]Fuhrer (2000) also uses a linear (additive) form, while Kozicki and Tinsley (2002) use a logarithmic (geometric) form.

[6]When $\theta = 0$, then $z_t = z_{t-1} = const$, so the model is equivalent to a model without habits; when $\theta = 1$, then $z_t = c_{t-1}$ so the model collapses to a setup where the habit term is simply the past level of consumption.

takes the two tax rates $\{\tau^c, \tau^y\}$, government spending categories, $\{g_t^c, g_t^t\}_{t=0}^{\infty}$, profit $\{\pi_t\}_{t=0}^{\infty}$, the realized technology process $\{A_t\}_{t=0}^{\infty}$, prices $\{w_t, r_t\}_{t=0}^{\infty}$, and chooses $\{c_t, h_t, k_{t+1}\}_{t=0}^{\infty}$ to maximize its utility subject to the budget constraint.[7] After plugging the process followed by habits into the utility function, the constraint optimization problem generates the following optimality conditions:

$$c_t \ : \ (c_t/z_t^{\phi})^{-\sigma} z_t^{-\phi} + \beta\phi\theta(c_{t+1}/z_{t+1}^{\phi})^{-\sigma} c_{t+1} z_{t+1}^{-\phi-1} = \lambda_t(1+\tau^c) \tag{2.7}$$

$$h_t \ : \ \frac{\gamma}{1-h_t} = \lambda_t(1-\tau^y)w_t \tag{2.8}$$

$$k_{t+1} \ : \ \lambda_t = \beta E_t \lambda_{t+1}[1 + (1-\tau^y)r_{t+1} - \delta] \tag{2.9}$$

$$TVC \ : \ \lim_{t\to\infty} \beta^t \lambda_t k_{t+1} = 0 \tag{2.10}$$

$$z_{t+1} \ : \ z_{t+1} = z_t - \theta(c_t - z_t) \tag{2.11}$$

where λ_t is the Lagrangean multiplier attached to household'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 (taking into consideration the effect of habits) 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 fourth condition is called the "transversality condition" (TVC): it states that at the end of the horizon, the value of physical capital should be zero. Lastly, for clarity of exposition, we include the process followed by the habits term.

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, and labor hours, h_t, to maximize static profit

$$\Pi_t = A_t k_t^{\alpha} h_t^{1-\alpha} - r_t k_t - w_t h_t, \tag{2.12}$$

[7]Note that by choosing k_{t+1} the household is implicitly setting investment i_t optimally.

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.*:

$$k_t \quad : \quad \alpha \frac{y_t}{k_t} = r_t, \tag{2.13}$$

$$h_t \quad : \quad (1-\alpha)\frac{y_t}{h_t} = w_t. \tag{2.14}$$

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

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:

$$g_t^c + g_t^t = \tau^c c_t + \tau^y [w_t h_t + r_t k_t] \tag{2.15}$$

Tax rates and government consumption-to-output ratio would be chosen to match the average share in data, and government transfers would be determined residually in each period so that the government budget is always balanced.

2.4 Dynamic Competitive Equilibrium (DCE)

For a given process followed by technology $\{A_t\}_{t=0}^{\infty}$ average tax rates $\{\tau^c, \tau^y\}$, initial capital stock $\{k_0\}$, lagged consumption $\{c_{-1}\}$, the decentralized dynamic competitive equilibrium is a list of sequences $\{c_t, i_t, k_t, h_t\}_{t=0}^{\infty}$ for the household, 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 (i) the household maximizes its utility function subject to its budget constraint; (ii) the representative firm maximizes profit; (iii) government budget is balanced in each period; (iv) all markets clear.

3 Data and Model Calibration

To characterize business cycle fluctuations with an endogenous depreciation rate in Bulgaria, we will focus on the period following the introduction of the currency board (1999-2016). Quarterly data on output, consumption and investment was collected from National Statistical Institute (2017), while the real interest rate is taken from Bulgarian National Bank Statistical Database (2017). The calibration strategy described in this section follows a long-established tradition in modern macroeconomics: first, as in Vasilev (2016), 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 (2015b), 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 income tax rate was set to $\tau^y = 0.1$. This is the average effective tax rate on income between 1999-2007, when Bulgaria used progressive income taxation, and equal to the proportional income tax rate introduced as of 2008. Similarly, the tax rate on consumption is set to its value over the period, $\tau^c = 0.2$. As in Hansen and Singleton (1983), the curvature of the utility function was set to $\sigma = 2$. Following Fuhrer (2000) and Carroll (2001), the habit persistence parameter was set to $\phi = 0.8$, and the degree of convergence of habits was set to $\theta = 0.2$. Next, the relative weight attached to the utility out of leisure in the household's utility function, γ, 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 2015a) as well over the period studied. Net, the steady-state depreciation rate of physical capital in Bulgaria, $\delta = 0.013$, was taken from Vasilev (2016). It was estimated as the average quarterly depreciation rate over the period 1999-2014. 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

Table 1: Model Parameters

Parameter	Value	Description	Method
β	0.982	Discount factor	Calibrated
σ	2.000	Curvature, utility function	Set
ϕ	0.800	Importance of consumption habits	Set
α	0.429	Capital Share	Data average
$1-\alpha$	0.571	Labor Share	Calibrated
δ	0.013	Depreciation rate on physical capital	Data average
ϕ	0.800	Habit persistence parameter	Set
τ^y	0.100	Average tax rate on income	Data average
τ^c	0.200	VAT/consumption tax rate	Data average

are reported in Table 2 on the next page. 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 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 Stability of Equilibrium Dynamics

The equilibrium system is now log-linearized around its unique deterministic steady-state, and after shutting down all stochasticity, and after some simplification, it can be represented by a system of four first-order difference equations in consumption, habit term, shadow price

Table 2: Data Averages and Long-run Solution

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

of wealth (Lagrangean multiplier), and physical capital:

$$\begin{bmatrix} \hat{z}_{t+1} \\ \hat{c}_{t+1} \\ \hat{\lambda}_{t+1} \\ \hat{k}_{t+1} \end{bmatrix} = M \begin{bmatrix} \hat{z}_{t} \\ \hat{c}_{t} \\ \hat{\lambda}_{t} \\ \hat{k}_{t} \end{bmatrix} \tag{5.1}$$

where the elements of matrix M are functions of the model parameters. There are four distinct and real characteristic roots, which for Bulgaria take the following values:

$$\mu_1 = 0.96, \mu_2 = -0.78, \mu_3 = 0.94, \mu_4 = 0.01 \tag{5.2}$$

Given that the reduced-form representation of the equilibrium system features four characteristic roots that are less than unity, the model features global stability (indeterminacy or "sink dynamics").[8]

6 Discussion

In this section we argue that the model discussed in this paper with habits in consumption is an isomorphic problem to a setup with increasing returns to scale. The way habits enter the

[8]The results are robust to variations in parameters σ, ϕ and θ.

model makes them a state variable. In turn, consumption also becomes forward-looking.[9] In addition, depending on the initial level of habits, h_0, there are many equilibrium paths leading to the unique steady state, but some are characterized with high- and some feature low consumption levels. Furthermore, the process followed by the habits term affects the marginal rate of substitution between consumption and leisure, and acts like a taste shock.[10,11] In addition, the habits terms affects the path followed by the shadow price of consumption, λ_t, which is also the price of capital. In turn, the equilibrium rental rate is also affected, as well as the wage rate. So if we map consumption into output using some "technology", say the Keynesian propagation mechanism, then we do have increasing returns to scale, as consumption will change a little, while output will change a lot because even though the marginal propensity to consume is low, the spending multiplier is still larger than unity (and because labor and capital will change a lot). Farmer (1999) has also shown that the presence of IRS can produce indeterminate equilibria, as long as the increasing returns are large enough.

So even after shutting down aggregate uncertainty, extrinsic uncertainty (uncertainty that does not affect model primitives) may matter for equilibrium. In other words, knowledge of fundamentals in a model with consumption habits, which enter multiplicatively the representative agent's utility function, does not allow us to determine the equilibrium consumption path, as it will be determined by how people coordinate their expectations. For example, given certain beliefs, different allocations can be produced, even though nothing fundamental has changed. These are also called "self-fulfilling prophesies," which are at the core of the

[9]The presence of habits implies that consumers in the model wish to smooth their consumption growth in an optimal way. As argued in Carroll (2001), with strong enough habit motive, the marginal propensity to consume out of permanent income is much less than unity. Alternatively, as in Carroll and Kimbal (1996), the consumption function is concave, and there is a "precautionary savings" motive (Kimball 1990). They also show that utility of consumption is a function (geometric mean more specifically) of both the level and the growth rate of consumption. For feasible values of the habit importance parameter, i.e., $\phi \in (0, 1)$, both moments are important.

[10]Furthermore, Bencivenga (1992) argues that taste shocks might be a useful shortcut, aiming to capture something unobservable, such as technology shocks to the home production function, e.g. Benhabib *et al.* (1991). In a way, habits also act in the model like an endogenous technology shock.

[11]Note that since in equilibrium $MRS = MRTS$, the right-hand-side has to adjust as well.

Keynesian view of business cycles. In some cases agents in the economy might be possessed by "animal spirits", either being under the influence of "irrational exuberance," or in other cases (such as the context of Bulgaria) agents in the economy might be suffering a severe form of pessimism about the future. The belief that the future will not be much better than today, which could be a trait of a conservative culture, turns out to be a powerful tool that can sustain low consumption and output in equilibrium.[12] Indeed, if expected productivity is low, labor supply and investment will also be low, and thus the pessimistic belief will be validated (self-fulfilling).[13]

A serious limitation of this theory that needs to be acknowledged, is that expectations (and habits for that matter) are not directly observable, as they are not part of the primitives of the model. So there is still a lot of work to be done. One possible venue for further research could be the one pointed out in Farmer (1999): in particular, one reason for such beliefs to occur in our model could be the outcome of incomplete participation. In other words, despite the existence of complete set of markets, agents may not be allowed to transact and trade labor services in all of them, due to some frictions in the capital and labor markets. These imperfections keep the expected returns lower, and future consumption and output levels stay low. In order to achieve saddle-path stability in the economy, those rigidities in the factor markets need to be addressed first. Yet another possibility to break the multiplicity result is to attempt to support the positive expectations about the future, for example by lowering taxes and government spending, which as argued in King and Rebello (1990) and Vasilev (2016), would increase after-tax returns to the factors of production and stimulate consumption and investment.[14] Such explorations, however, will be left for future research.

[12]Note that with multiplicative habits, the degree of risk aversion is much larger, which is consistent with anecdotal evidence in Bulgaria.

[13]Path dependence may also be importance. If the economy starts with low habits, that might be because it is stuck in a "low equilibrium" trap, and it cannot depart from it without an outside "nudge."

[14]Re-introducing progressive taxation in Bulgaria will not break the multiplicity result either - we experimented with the degree of progressivity featured by the progressive regime from before the introduction of proportional taxation, which is taken as the maximum degree of progressivity that the society was willing to accept). This negative result is in contrast to Guo and Lansing (1988) who argue that progressive taxation works as an automatic stabilizer.

7 Conclusions

We introduce consumption habits into an exogenous growth model augmented with a detailed government sector, and calibrate the model to Bulgarian data for the period following the introduction of the currency board arrangement (1999-2016). We show that in contrast to the case without habits, *e.g.*, Vasilev (2009), when the economy features saddle-path stability, the habit motive alone leads to equilibrium indeterminacy in the model. When habits enter multiplicatively in the representative agent's utility function, the setup exhibits "sink" dynamics, and equilibrium paths are determined by "animal spirits." These results are in line with the findings in the literature, *e.g.*, Benhabib and Farmer (1994, 1996) and Farmer (1999), and have major implications for polcy-making and welfare.

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