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Progressive taxation and (in)stability in an exogenous growth model with Epstein-Zin recursive preferences

Aleksandar Vasilev*

Abstract

We show that in a exogenous growth model with Epstein-Zin (1989, 1991) recursive preferences calibrated to Bulgarian data under the progressive taxation regime (1993-2007), the economy exhibits equilibrium indeterminacy. These results are in line with the findings in Benhabib and Farmer (1994, 1996) and Farmer (1999). Also, the findings in this paper are in contrast to Guo and Lansing (1988) who argue that progressive taxation works as an automatic stabilizer. In contrast, under the flat tax regime (2008-16), the same economy calibrated to Bulgarian data now displays saddle-path stability. The decrease in the average effective tax rate addresses the indeterminacy issue and eliminates the "sink" dynamics.

Keywords: Progressive taxation; Epstein-Zin preferences; Equilibrium (In)determinacy; Bulgaria

JEL Classification Codes: H22, J46, D51, D91, O41

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1 Introduction and Motivation

Tax policies, and in particular personal income taxation policies, are known to affect households' incentives to invest in physical capital, and their decisions to provide labor services to businesses. The analysis of the effect of tax policies within the framework of exogenous growth models with a representative agent is relatively recent, *e.g.*, King and Rebelo (1990). This paper adds to earlier research by focusing on the interaction of Epstein-Zin recursive preference and the motive for so-called "early resolution of uncertainty" in an environment featuring progressive income taxation, which could produce interesting and novel results. Indeed, consumer preferences featured by households play a crucial role in any economic model, being an important part of the set of model primitives (which is comprised of preferences, endowments, and technology); after all, we derive consumers' optimal decision rules from those. In addition, preferences describe an explicit objective, against which we evaluate the quantitative effects of different tax policies.

Furthermore, as pointed in Weil (1990), researchers in macroeconomics should distinguish between risk aversion and the willingness to substitute consumption over time in their models. After all, the two parameters are distinct features of household's preferences, and should be parameterized separately from each other. However, in the usual formulation with time-separable preferences, one is reciprocal of the other. This is a problem as in data both a low elasticity of inter-temporal substitution, and low risk aversion have been measured. One way to address that issue is to use a *generalized isoelastic utility function*, which has constant (but unrelated) coefficients of risk aversion and elasticity of intertemporal substitution.[1]

In this paper we will take this class of preferences seriously, and proceed to investigate their quantitative importance for fiscal policy issues. As in Chen and Guo (2015) and Vasilev (2016), the focus in this paper is to examines the instability effect of progressive taxation in the case of Bulgaria pre-2008 and compare and contrast the results to the flat tax reform regime in place as of 2008. While our findings are qualitatively similar to that in Chen and Guo (2013, 2015), here the mechanism is based on the Epstein-Zin recursive preferences and

[1] Furthermore, those functions feature so-called recursive preferences, and with those preferences households would like the outcome of an uncertain event (lottery) to be revealed earlier, instead of later.

the motive for so-called "early resolution of uncertainty."[2] Our results come in stark contrast to Guo and Lansing (1988) who argue that a sufficiently progressive tax schedule can stabilize a real-business-cycle model, which possesses an indeterminate steady-state against fluctuations driven by "animal spirits." Indeed, in standard Keynesian setups, progressivity of the tax system is regarded as an automatic stabilizer. This is no longer the case in our model with Epstein-Zin recursive preferences. When we calibrate the model to Bulgarian data for the period that featured a progressive income taxation regime (1993-2007), and find that the economy exhibits equilibrium indeterminacy. The reason is that recursive preferences produce endogenous variation in the marginal rate of substitution, and that acts like a sector-specific externality, which could create indeterminacy through increasing-returns-to-scale effects. These results for Bulgaria under the progressive income taxation regime are therefore in line with the findings in Benhabib and Farmer (1994, 1996) and Farmer (1999). In contrast, under the flat tax regime (2008-16), the same economy calibrated to Bulgarian data now displays saddle-path stability. The decrease in the average effective tax rate addresses the indeterminacy issue and eliminates the "sink" dynamics.[3]

The theoretical setup used in this paper to study the flat tax reform in Bulgaria follows the setup in Vasilev (2018), and augments their framework with a sufficiently-detailed government sector to capture the distortionary effect of personal income taxation in Bulgaria. From early 1990s, up until Dec. 31, 2007, Bulgaria applied progressive income taxation on personal income,[4] with tax brackets for 2007 reported in Table 1 on the next page. As of January 1, 2008, a proportional (flat) tax rate of 10% on personal income was introduced. To compensate workers at the bottom of the income distribution, who suddenly faced a

[2]For more on this, see Kreps and Porteus (1978).

[3]Following the work of Hall (1997), Nakajima and Rios-Rull (2005) provides a microfoundation for the marginal-rate-of-substitution shift showing that a representative agent model that features such a shock "can be viewed as a reduced form of a heterogeneous-agents economy with incomplete markets." On the other hand, Gourio (2012) provides a very appealing microfoundation for the discounting shock as he shows that time varying impatience parameters may be interpreted as a reduced form of a model that features a time varying probability of some economic disaster which plays a critical role in the agents' (relative) assessment of investment alternatives.

[4]The description of the progressive tax system in Bulgaria in this section follows the structure used in Vasilev (2015a).

Table 1: Progressive Income Taxation in Bulgaria in 2007

Monthly taxable income (in BGN)	Tax owed
0-200	Zero-bracket amount
200-250	20% on the amount earned above BGN 200
250-600	BGN 10 + 22% on the excess over BGN 250
> 600	BGN 87 + 24% on the excess over BGN 600

positive tax rate, the monthly minimum wage was increased: it went up in several steps eventually reaching BGN 510 as of Jan. 2018. Overall, under proportional taxation system featuring a lower effective income tax rate than the corresponding rate under the progressive regime, led to an increase in the after-tax return to labor. In addition, since labor and capital are complements in the production of registered output at the aggregate level, the increase employment that followed, also increases the marginal productivity of capital. In turn, the higher return to physical capital provides a strong incentive for households to increase capital accumulation, thus enhancing the productive capacity of the economy. This generates a saddle-path dynamics by decreasing the magnitude of the increasing returns to scale due to the presence of recursive preferences featuring a motive for an "early resolution of uncertainty."

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 under both the progressive and proportional income taxation regimes. Section 5 evaluates the model stability around the steady-state for both the progressive taxation and flat-tax regimes. Section 6 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 uses a progressive schedule to tax all income, in order to finance wasteful (unproductive) purchases of government consumption goods,[5] 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 a utility function, which features recursive preferences as in Epsten and Zin (1989, 1991) and Weil (1990):

$$V_t = \left[(1-\beta)[c_t^{\nu}(1-h_t)^{1-\nu}]^{\frac{1-\gamma}{\theta}} + \beta[E_t V_{t+1}^{1-\gamma}]^{\frac{1}{\theta}} \right]^{\frac{\theta}{1-\gamma}} \tag{2.1}$$

where

$$\theta = \frac{1-\gamma}{1-\frac{1}{\psi}}, \tag{2.2}$$

and V_t is the value function as of period t, $0 < \nu, 1-\nu < 1$ are the utility weights attached to consumption and leisure, respectively; $[E_t V_{t+1}^{1-\gamma}]^{\frac{1}{\theta}}$ is the *risk-adjusted* expectation operator at of period t, c_t denotes household's private consumption in period t, h_t are hours worked in period t, $0 < \beta < 1$ is the discount factor.[6]

With Epstein-Zin preferences, the elasticity of intertemporal substitution (EIS), and the coefficient of relative risk aversion (CRRA) are separated. More specifically, $\gamma \geq 0$ is the parameter that controls risk aversion, while $\psi \geq 0$ is the IES.[7] Note that for values of $\gamma > 1$, and $\psi > 1$, the agent has a preference for "an early resolution of uncertainty" (Kreps and Porteus 1978, Weil 1990).[8] In other words, the household is averse to volatility in future

[5]We could easily extend the setup to one, where government services are a source of utility for the household, separable from private consumption and leisure. Since we focus on exogenous (observed) policies, the results obtained in such a case will be identical to the ones reported here.

[6]Importantly, these preferences are stationary in the sense of Koopmans (1960).

[7]Therefore, this class of preferences responds to Hall's (1988) critique. In contrast, with other functional forms the elasticity of substitution and the coefficient of relative risk aversion are reciprocals of one another.

[8]Note that, as in Epstein and Zin (1991), early resolution of uncertainty requires

$$1-\gamma < 1-\frac{1}{\psi} \quad \text{or} \quad \frac{1}{\psi} < \gamma \tag{2.3}$$

For $\psi, \gamma > 1$ the condition above is satisfied.

utility, and more specifically, the recursive utility formulation adds curvature with respect to future risks.

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

$$k_{t+1} = i_t + (1 - \delta)k_t \tag{2.4}$$

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

$$\max_{\{c_t, h_t, k_{t+1}\}_{t=0}^{\infty}} V_t = \left[(1 - \beta)[c_t^{\nu}(1 - h_t)^{1-\nu}]^{\frac{1-\gamma}{\theta}} + \beta[E_t V_{t+1}^{1-\gamma}]^{\frac{1}{\theta}} \right]^{\frac{\theta}{1-\gamma}} \tag{2.5}$$

s.t.

$$(1 + \tau^c)c_t + k_{t+1} - (1 - \delta)k_t = (1 - \tau(y_t))[w_t h_t + r_t k_t] + g_t^t + \pi_t \tag{2.6}$$

where τ^c is the tax on consumption, $\tau(y_t)$ is the progressive tax rate levied on income, and where, as in Guo and Lansing (1998), tax schedule is represented by the following function:

$$\tau(y_t) = \eta \left(\frac{y_t}{y} \right)^{\phi}, \tag{2.7}$$

where $0 < \eta < 1$ and $0 \leq \phi < 1$, where ϕ measures the progressivity of the tax system, and η is the average effective tax rate in steady state. Lastly, g_t^t denotes government transfers. The household takes the two tax schedules $\{\tau^c, \tau(y_t)\}$, 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.[9] The

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

constraint optimization problem generates the following optimality conditions:

$$
\begin{aligned}
V_t \quad &: \quad V_t - \left[(1-\beta)[c_t^{\nu}(1-h_t)^{1-\nu}]^{\frac{1-\gamma}{\theta}} + \beta[E_t V_{t+1}^{1-\gamma}]^{\frac{1}{\theta}}\right]^{\frac{\theta}{1-\gamma}} = 0 && (2.8) \\
c_t \quad &: \quad \nu\left[(1-\beta)[c_t^{\nu}(1-h_t)^{1-\nu}]^{\frac{1-\gamma}{\theta}} + \beta[E_t V_{t+1}^{1-\gamma}]^{\frac{1}{\theta}}\right]^{\frac{\theta}{1-\gamma}-1} \times \\
&\quad (1-\beta)c_t^{\frac{\nu(1-\gamma)}{\theta}-1}(1-h_t)^{\frac{(1-\nu)(1-\gamma)}{\theta}} = \lambda_t(1+\tau^c) && (2.9) \\
h_t \quad &: \quad (1-\nu)\left[(1-\beta)[c_t^{\nu}(1-h_t)^{1-\nu}]^{\frac{1-\gamma}{\theta}} + \beta[E_t V_{t+1}^{1-\gamma}]^{\frac{1}{\theta}}\right]^{\frac{\theta}{1-\gamma}-1} \times \\
&\quad (1-\beta)c_t^{\frac{\nu(1-\gamma)}{\theta}}(1-h_t)^{\frac{(1-\nu)(1-\gamma)}{\theta}-1} = \lambda_t[1-(1+\phi)\tau(y_t)]w_t && (2.10) \\
k_{t+1} \quad &: \quad \lambda_t = \beta E_t \lambda_{t+1}\left[1 + [1-(1+\phi)\tau(y_{t+1})]r_{t+1} - \delta\right] && (2.11) \\
TVC \quad &: \quad \lim_{t\to\infty} \beta^t \lambda_t k_{t+1} = 0 && (2.12)
\end{aligned}
$$

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, besides caring for the short-run (period t vs. period $t+1$ utility), the household cares also for the "long run", in the sense that the entire sequence of future consumption and leisure - captured by the continuation value - directly affects the state of the economy in $t+1$. 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.

2.2 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

$$\Pi_t = A_t k_t^{\alpha} h_t^{1-\alpha} - r_t k_t - w_t h_t, \tag{2.13}$$

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.*:

$$k_t \quad : \quad \alpha \frac{y_t}{k_t} = r_t, \tag{2.14}$$

$$h_t \quad : \quad (1-\alpha)\frac{y_t}{h_t} = w_t. \tag{2.15}$$

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:

$$g_t^c + g_t^t = \tau^c c_t + \tau(y_t)[w_t h_t + r_t k_t] \tag{2.16}$$

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 $\{A_t\}_{t=0}^{\infty}$, tax schedules $\{\tau^c, \tau(y_t)\}$, initial capital stock $\{k_0\}$, initial level of the value function $\{V_0\}$, 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

The model is calibrated to Bulgarian data at quarterly frequency. The period under investigation is 1993-2016, where 1993-2007 is when taxation was progressive, and 2008-16 is the flat tax regime. 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 (2017), 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, we compute the average effective tax rate $\eta = 0.14$ and the (gross) degree of progressivity was computed to be $1 + \phi = 1.43$ for the progressive regime, and $\eta = 0.11$, $\phi = 0$ for the flat tax. Similarly, the tax rate on consumption is set to its value over the period, $\tau^c = 0.2$. As in Herberger (2013), the relative risk aversion parameter and the IES are set to $\gamma = 2$ and $\psi = 0.043$, respectively. Next, the relative weight attached to the utility out of consumption in the household's utility function, ν, 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 2018b) 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 1999-2016. Lastly the level of total factor productivity will be held at a constant level. Table 2 on the next page 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

Table 2: Model Parameters

Parameter	Value	Description	Method
β	0.982	Discount factor	Calibrated
α	0.429	Capital Share	Data average
$1-\alpha$	0.571	Labor Share	Calibrated
γ	2.000	Relative risk aversion parameter	Set
ψ	0.043	Intertemporal elasticity of substitution	Set
δ	0.013	Depreciation rate on physical capital	Data average
η	$\{0.11; 0.14\}$	Average effective income tax rate (flat vs. progr.)	Data average
ϕ	$\{0; 0.43\}$	Progressivity parameter (flat vs. progr.)	Data average
τ^c	0.200	VAT/consumption tax rate	Data average

reported in Table 3 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 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 $\bar{r} = (1-\eta)r - \delta$ 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 the continuation value function term,

Table 3: 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

physical capital, shadow price of wealth (Lagrangean multiplier), and hours:

$$\begin{bmatrix} \hat{V}_{t+1} \\ \hat{k}_{t+1} \\ \hat{\lambda}_{t+1} \\ \hat{h}_{t+1} \end{bmatrix} = M \begin{bmatrix} \hat{V}_t \\ \hat{k}_t \\ \hat{\lambda}_t \\ \hat{h}_t \end{bmatrix} \tag{5.1}$$

where the elements of matrix M are functions of the model parameters. There are four distinct and real characteristic roots, which for Bulgaria under the progressive taxation regime (1993-2007) take the following values:

$$\mu_1 = 0.07, \mu_2 = 0.98, \mu_3 = -0.24, \mu_4 = 0.01 \tag{5.2}$$

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").[10] Intuitively, this means that the Bulgarian economy under the progressive taxation regime can reach the steady state with either high or low consumption. As in Farmer (1999), the recursivity of Epstein-Zin preferences produces an increasing returns to scale effect, due to the endogenously-varying discount factor (and the marginal rate of substitution). That external effect is also akin to a sector-specific externality.

[10]The results are robust to variations in parameters σ and ψ.

In contrast, for Bulgaria under the proportional (flat) tax regime (2008-2014) we obtain:

$$\mu_1 = 0.08, \mu_2 = 1.02, \mu_3 = -0.25, \mu_4 = 0.01 \tag{5.3}$$

Now the model exhibits saddle-path stability, with three stable and one unstable root. Under proportional taxation, which features a lower effective tax rate, there are no increasing-returns to scale effects. We discuss the results for the (lack of) indeterminacy in detail in the following section.

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. With recursive preferences a la Epstein and Zin (1989, 1991), the value function itself becomes a state variable through the continuation value. In turn, consumption also becomes forward-looking. In addition, depending on the initial level of utility, V_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, with recursive Epstein-Zin preferences the marginal rate of substitution between consumption and leisure varies endogenously, and acts like a taste shock.[11,12] 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.

[11] 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, recursive preferences themselves also act in the model like an endogenous technology shock.

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

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 Epstein-Zin recursive preferences 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 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.

A serious limitation of this theory that needs to be acknowledged, is that expectations (and recursive preferences for that matter) are not directly observable, 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 markets, such as the ones for insurance, and thus households' preference for early resolution of uncertainty plays an important role. Following the work of Hall (1997), Nakajima and Rios-Rull (2005) provide a microfoundation for the marginal-rate-of-substitution shift showing that a representative agent model that features such a shock "can be viewed as a reduced form of a heterogeneous-agents economy with incomplete markets." On the other hand, Gourio (2012) provides a very appealing microfoundation for the discounting shock as he shows that time varying impatience parameters may be interpreted as a reduced form of a model that features a time varying probability of some economic disaster which plays a critical role in the agents' (relative) assessment of investment alternatives. Therefore, missing markets, together with progressive taxation, may be the factors that 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, or corrected by introducing proportional ("flat") income tax schedule.

Thus, issues of indeterminacy and the choice of particular income tax regime have major implications for policy-making and welfare.

7 Conclusions

We show that in a exogenous growth model with Epsten-Zin (1989, 1991) recursive preferences calibrated to Bulgarian data under the progressive taxation regime (1993-2007), the economy exhibits equilibrium indeterminacy. These results are in line with the findings in Benhabib and Farmer (1994, 1996) and Farmer (1999). Also, the findings in this paper are in contrast to Guo and Lansing (1988) who argue that progressive taxation works as an automatic stabilizer. In contrast, under the flat tax regime (2008-16), the same economy calibrated to Bulgarian data now displays saddle-path stability. The decrease in the average effective tax rate addresses the indeterminacy issue and eliminates the ”sink” dynamics.

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