A Real-Business-Cycle model with institutional quality: The Case of Bulgaria (1999-2018)

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Abstract

This paper takes an otherwise standard real-business-cycle (RBC) setup with government sector, and augments it with an output-expropriation mechanism and shocks to institutional quality in order to study business cycle fluctuations. The extraction decision is endogenous: households can use their time either productively, or engage in opportunistic activities. Stronger institutions decrease the size of the available resources for capture, and suppress corrupt behavior. As a test case, the model is calibrated to Bulgaria after the introduction of the currency board (1999-2018). Overall, the shocks to institutional quality generate business cycles of the same magnitude as in data, which suggests that political economy factors might be the major driving force behind the observed economic fluctuations in Bulgaria. Another interesting result, generated by the model, is that on average, the estimated size of evaded resources is approximately one-fourth of output, which is very close to the estimates of the unofficial economy share, *e.g.*, European Commission (2014) and Medina and Schneider (2017).

Keywords: institutional quality, business cycles, output evasion, Bulgaria

JEL Classification Codes: E32, E26, E62, H26

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1 Introduction and Motivation

The standard real-business-cycle (RBC), driven solely by innovations to total factor productivity,[1] does not describe well business cycles in developing economics. Thus, even though emerging economies feature economic fluctuations at business cycle frequencies very similar to those in the developed world, the major driving force needs to be a factor different and separate from technology. We believe that the explanation lies with institutions. In particular, developing countries have notorious problems with the quality of their institutions, and the variation in that quality is a potential candidate for an alternative source of the business cycle, or "political" business cycles.[2] In addition, interest groups are better organized than the general electorate even in fully-fledged democratic regimes, and may extract rents from the latter, *e.g.* Persson and Tabellini (2000), Mueller (2003), and Hillman (2018). We take this line of research seriously, and proceed to investigate the quantitative importance of institutions for the propagation of business cycles. By using a micro-founded RBC model, we aim to contribute to the non-technical institutional literature, *e.g.* North (1990).[3]

In the model in this paper we start by taking the existence of institutional problems in the economy as an empirical fact. Those deficiencies could be easily mapped to problems with control of corruption (Mauro 1995), weak property rights (Angelopoulos *et al.* 2011), government efficiency, political stability, rule of law, *e.g.*, Persson and Tabellini (2000), among others. We will use them interchangeably in the text; More importantly, due to the institutional weaknesses, there are private resources ("contestable rents") that could be claimed

[1] Also referred to as "technology shocks," as argued by King and Rebelo (1999), and Rebelo (2005), among others.

[2] See Alesina *et al.* (1997), as well as the references therein. We are not going to model the political environment explicitly in the model. Nevertheless, the link between the government in office and the implementation of policies, should be evident. Furthermore, as pointed out in Park *et al.* (2005) and others, weak institutions are linked to ineffective legal systems, problems with contract enforcement, social polarization due to income inequality, among others. The interested reader is referred to Knack and Keefer (1995), Hall and Jones (1999), Easterly (2001), Tanzi (2002), and the references therein.

[3] We also contribute and extend the RBC literature, and responding to the suggestion made in Parente and Prescott (2000), and especially the one in Prescott (1998) that there is much need for a theory that endogeneizes total factor productivity (TFP), which as pointed in Abramovitz (1956), is "the measure of our ignorance."

and redistributed. In the model framework, self-interested individuals rationally decide to extract some of the resources for personal gain. By endogeneizing the extraction process, the theoretical setup predicts that as a result of corruption, the returns to production inputs - labor and capital - will be much lower than the social ones in the model, an observation which can be easily validated. This is because corruption has a direct and indirect effect on aggregate economic activity: first, it reduces directly the resources available, and second, it distorts the allocative process in a market economy by creating incentives for individuals to benefit from illegal activities and thus their productive effort is also reduced.

Lastly, to explore the quantitative effect of the mechanism described above, we decided to calibrate the model for Bulgaria. Despite being part of the EU, it is still the poorest member state, and is still developing. The institutional environment in Bulgaria is more volatile than in the West; e.g, as measured by the ICRG index,[4] the government efficacy is lower in Bulgaria relative to the rest of the EU member states. Furthermore, there is also plenty of anecdotal evidence that politics drives economic activity in Bulgaria. We thus explore how quantitatively important is the role of institutions for aggregate economic activity, and what is the exact channel through which the shock propagates (or amplifies other shocks) in the economy. We believe that our study will be of interest to other countries considering EU accession, as well as to other developing economies:[5] e.g., corruption perception is one of the highest in the EU, according to Transparency International (2019). Similarly, corruption in the model is akin to an output tax, and affects production and labor decision, investment and consumption levels, and leads to resource mis-allocation. Model-based simulations show that institutional shocks are equally-, if not more important than technology, to match business cycle fluctuations in Bulgaria. Therefore, political economy extensions to the standard RBC model provide a promising venue for further research.[6]

[4]This index was originally developed by Knack and Keefer (1995).

[5]Still, Bulgaria differs in important ways from other developing countries in the sense that as an EU member state and a fixed exchange rate to the Euro, there is virtually no exchange rate risk; there are also no wars, no internal conflicts, no major ethnic or religious tensions. Still, bureaucracy and government inefficiency are problems, which is costly when measured relative to private output.

[6]Given that the political economy literature pre-dates the rational expectations revolution, as pointed out by Alesina *et al.* (1997), so we can rationalize certain stylized facts by introducing those mechanisms in models for developing countries, *e.g.*, along the lines in Drazen (2000), within a disciplined, micro-founded

The rest of the paper is organized as follows: Section 2 describes the model setup, Section 3 describes the model calibration, Section 4 characterizes the symmetric steady-state, Sections 5 proceeds with the out-of-steady-state dynamics of model variables, and compares the simulated second moments of theoretical variables against their empirical counterparts, and Section 6 discusses some of the model assumptions and limitations. Section 7 concludes.

2 Model Description

The model in in the spirit of Economides *et al.* (2007), and Angelopoulos *et al.* (2011). In particular, there is a unit mass of identical households, who derive utility out of consumption and leisure. The time available to households can be spent in productive work, or in opportunistic activities, namely extraction of private resources. The government collects tax revenue, and spends on public purchases and government transfers. On the production side, there is a representative firm, which produces a homogeneous final good, which could be used for consumption, investment, or government purchases.

2.1 Households

There is a unit mass of one-member households, indexed by i. Each household i maximizes its utility function:[7]

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{[c_{it}^{\mu}(1-h_{it})^{1-\mu}]^{1-\sigma}}{1-\sigma} \right\}, \tag{1}$$

where E_0 is the expectations operator as of period $t=0$, c_{it} denotes household's i private consumption in period t, h_{it} are non-leisure hours in period t, $0<\beta<1$ is the discount factor, and $0<\mu, 1-\mu<1$ denote the weights that each household attaches to consumption and leisure, respectively.

general equilibrium framework, where agents are rational forward-looking optimizers.

[7]Without loss of any generality, we can add an additive term featuring government purchases in the household's utility function. However, since the focus in this paper is on exogenous (observed) policies, the results are unaffected.

Each household i starts with an initial stock of physical capital k_{i0}, and has to decide how much to grow it through investment. Physical capital depreciates at a rate δ each period, where $0 < \delta < 1$. The law of motion for physical capital is then described by the following equation:

$$k_{i,t+1} = i_{it} + (1-\delta)k_{it}. \tag{2}$$

Households rent capital to the firm at the real interest rate r_t, hence the before-tax capital income of household i in period t equals $r_t k_{it}$.

In addition to capital income, each household can generate labor income. However, not all hours are spent in productive activities: only η_{it} share, $0 < \eta_{it} < 1$, is dedicated to working in the representative firm, where the hourly wage rate is w_t, so household's labor income equals $w_t \eta_{it} h_{it}$. The remaining hours, $(1-\eta_{it})h_{it}$, are used to engage in expropriation. The reward from engaging in such activities is that the household can appropriate certain resources, measured as a share of aggregate output, and thus augment its income. The rent-extraction mechanism, R_t, is represented by the following technology, which is akin to the one used in Mueller (2003) and Angelopoulos *et al.* (2009, 2011):

$$R_t = \frac{(1-\eta_{it})h_{it}}{\sum_i (1-\eta_{it})h_{it}} \theta_t Y_t. \tag{3}$$

where θ_t is the time-varying economy-wide degree of rent-seeking via corrupt activities, and Y_t denotes aggregate output.[8] The fraction $\frac{(1-\eta_{it})h_{it}}{\sum_i (1-\eta_{it})h_{it}}$ would represents the contestable function, *i.e.*, the endogenous probability of winning the "prize" (or getting a larger per-household proportion of the total "pie"). Every household takes the time spent rent-seeking by the other households as given, and optimally chooses time directed to increasing the probability of winning.[9]

[8] This social interaction can be interpreted as a non-cooperative redistributive game, which features "strategic complementarities," *e.g.* Cooper and John (1988). In other words, there is a positive relationship between overall corruption activity and individual decision how much to engage in illegal activities. Since the individual household is assumed to be small relative to the population size, aggregate variables and the total amount of the rent are taken as given.

[9] Note that we assume that the government can collect what is owed to it, but due to weaknesses in the legal system, or corruption, people can "redistribute" some of the private resources to their own pockets.

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

$$\sum_{t=0}^{\infty} \beta^t \left\{ \frac{[c_{it}^{\mu}(1-h_{it})^{1-\mu}]^{1-\sigma}}{1-\sigma} \right\} \tag{4}$$

s.t.

$$(1+\tau^c)c_{it} + k_{i,t+1} - (1-\delta)k_{it} = (1-\tau^y)[w_t\eta_{it}h_{it} + r_t k_{it} + \pi_{it}] + g_{it}^t + \theta_t Y_t \frac{(1-\eta_{it})h_{it}}{\sum_i (1-\eta_{it})h_{it}}, \tag{5}$$

where g_{it}^t is household i's government transfer, and π_{it} is the profit income earned by each household. The problem generates the following optimality conditions:

$$c_{it} \quad : \quad c_{it}^{\mu(1-\sigma)-1}(1-h_{it})^{(1-\mu)(1-\sigma)} = \lambda_t(1+\tau^c) \tag{6}$$

$$k_{i,t+1} \quad : \quad \lambda_t = \beta\lambda_{t+1}[1 + (1-\tau^y)r_{t+1} - \delta] \tag{7}$$

$$\eta_{it}h_{it} \quad : \quad c_{it}^{\mu(1-\sigma)}(1-h_{it})^{(1-\mu)(1-\sigma)-1} = \lambda_t(1-\tau^y)w_t \tag{8}$$

$$(1-\eta_{it})h_{it} \quad : \quad c_{it}^{\mu(1-\sigma)}(1-h_{it})^{(1-\mu)(1-\sigma)-1} = \lambda_t\theta Y_t \frac{1}{\sum_i (1-\eta_{it})h_{it}} \tag{9}$$

$$TVC \quad : \quad \lim_{t\to\infty} \beta^t \lambda_t k_{i,t+1} = 0, \tag{10}$$

where λ_t is the Lagrangian multiplier attached to household i's budget constraint in period t.

The interpretation of the optimality conditions above is standard: the first one states that for each household, the marginal utility of consumption equals the marginal utility of wealth, corrected for the presence of consumption taxation. The second equation is called the "Euler condition," which describes how each household would optimally choose to allocate physical capital over time. Next, at the margin, each hour spent 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. Similarly, at the margin, an hour spent rent-seeking should equate the benefit - in terms of extracted rent - and the utility cost. The last condition is a terminal/boundary condition, also called the "transversality condition" (TVC), which is imposed to ensure stability of the solution. It states that at the end of the horizon, the value of physical capital should be zero, hence it si not optimal either to leave behind any capital, or borrow ever increasing amounts of capital.

2.2 Firm

There is a representative firm in the economy, which produces a homogeneous final product. The price of output is normalized to unity in each period. The production technology is Cobb-Douglas and uses both physical capital, k^f, and labor hours, h^f, to maximize static profit[10]

$$\Pi_t = (1-\theta_t)A_t(k_t^f)^{\alpha}(h_t^f)^{1-\alpha} - r_t k_t^f - w_t h_t^f, \tag{11}$$

where A_t denotes the level of technology in period t. Note that θ_t share of output is expropriated in each period by households. Therefore, rent-seeking is like a tax on output. Next, 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 ($\Pi_t = \pi_{it} = 0$), and each input is priced according to its marginal product, *i.e.*:

$$k_t^f \quad : \quad (1-\theta_t)\alpha\frac{y_t}{k_t^f} = r_t, \tag{12}$$

$$h_t^f \quad : \quad (1-\theta_t)(1-\alpha)\frac{y_t}{h_t^f} = w_t. \tag{13}$$

Note that, relative to the case with no output evasion, with corruption, the marginal returns on the factors of production are lower. Corruption acts like a tax on output, decreasing wages and interest rate, while at the same time creates a rent that can be appropriated. This creates the basis of the contest over the prize for which the households compete in Section 2.1.[11]

2.3 Government

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

$$g_t^c + \sum_i g_{it}^t = \tau^c \sum_i c_{it} + \tau^y \left[r_t \sum_i k_{it} + w_t \sum_i \eta_{it} h_{it} + \Pi_t \right] \tag{14}$$

[10]This is because the owners of capital are the households, who are also in charge of investment.

[11]Alternatively, the "prize" can be part of the tax revenue, e.g. VAT revenue, and households can compete to grab a share of the consumption tax revenue. For such a model, the interested reader is referred to Vasilev (2017d).

Government consumption-to-output ratio would be chosen to match the average share in data, so the level of purchases would vary with output, and government transfers would be determined residually in each period so that the government budget is always balanced.

2.4 Exogenous stochastic processes

The exogenous processes for total factor productivity, A_t, and institutional quality, θ_t, will follow AR(1) processes in natural logarithms:

$$\ln A_{t+1} = (1-\rho_a)\ln A + \rho_a \ln A_t + \epsilon^a_{t+1} \tag{15}$$

$$\ln \theta_{t+1} = (1-\rho_\theta)\ln \theta + \rho_\theta \ln \theta_t + \epsilon^\theta_{t+1}, \tag{16}$$

where A, θ are the steady-state values of the two processes, $0 < \rho_a, \rho_\theta < 1$ are the respective persistence parameters, and the productivity innovations and changes to institutional quality are drawn from the following distributions: $\epsilon^a_t \sim i.i.dN(0, \sigma^2_a)$ and $\epsilon^\theta_t \sim i.i.dN(0, \sigma^2_\theta)$, respectively.

2.5 Market Clearing

In addition to the optimality conditions from the household's 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 (i) aggregate quantities equal the sum of individual allocations, and (ii) output, capital and labor markets all clear, or for all t:

$$\sum_i \left[c_{it} + k_{i,t+1} - (1-\delta)k_{it}\right] + g^c_t = Y_t \tag{17}$$

$$\sum_i c_{it} = C_t \tag{18}$$

$$\sum_i g^t_{it} = g^t_t \tag{19}$$

$$\sum_i k_{it} = k^f_t = K_t \tag{20}$$

$$\sum_i \eta_{it} h_{it} = h^f_t = H_t. \tag{21}$$

2.6 Dynamic Competitive Equilibrium (DCE)

Given the processes followed by $\{A_t, \theta_t\}_{t=0}^{\infty}$, average tax rates $\{\tau^c, \tau^y\}$, initial individual capital endowments stock $k_{i0}, \forall i$, and aggregate allocations $\{Y_t, C_t, K_t, H_t\}_{t=0}^{\infty}$, the decentralized dynamic competitive equilibrium is a list of sequences $\{c_{it}, i_{it}, k_{it}, \eta_{it}, h_{it}\}_{t=0}^{\infty}$ for each household i, input levels $\{k_t^f, h_t^f\}$ chosen by the firm in each time period t, 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) each household i 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.

2.6.1 Symmetric DCE

In the general, non-symmetric, case it is very difficult to solve the system defined in the subsection above. More specifically, the model in its general formulation can generate a multitude of distributions of capital stock holdings across households, and in this sense, the equilibrium is indeterminate. Therefore, in order to break the multiplicity result, we will concentrate on a particular equilibrium, one in which all households are identical, *i.e.*, we will impose the symmetric solution. This requires setting $k_{i0} = k_0$, and imposing symmetry in the DCE system for all i, which in turn greatly simplifies the optimality conditions derived above. Since the model features a unit mass of households, this produces $y_{it} = Y_t, c_{it} = C_t, k_{it} = K_t, h_{it} = h_t, \eta_{it} = \eta_t$, etc. In addition, in the symmetric equilibrium every household will receive an equal share of the pie. Since the main objective is to make a prediction about the aggregate behavior of extraction activity, not how the degree of output evasion is distributed across the population, the focus on the symmetric DCE is not a significant limitation of the analysis.

3 Data and Model Calibration

To compute the size of overall tax evasion in Bulgaria, we will focus on the period after the introduction of the currency board (1999-2018). Data on output, consumption and investment was collected from National Statistical Institute (2019), while the real interest rate is obtained 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 (2016), the discount factor, $\beta = 0.937$, is set to match the steady-state capital-to-output ratio in Bulgaria, $k/y = 3.491$, in the steady-state consumption-Euler equation. The labor share parameter, $\alpha = 0.429$, is obtained as in Vasilev (2017d) as the average value of labor income in aggregate output.This value is slightly higher as compared to other studies on developed economies, due to the overaccumulation of physical capital.[12]

As in Kydland (1995), the weight attached to the utility out of consumption in the household's utility function, μ, 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 as well (Vasilev 2017a) over the period studied. The value for the curvature of the utility function was set to a standard value, $\sigma = 2$. Next, the depreciation rate of physical capital in Bulgaria, $\delta = 0.05$, was estimated as the average depreciation rate over the period 1999-2018. The share of working time used in rent-extraction, $1 - \eta = 0.4$, was set as the average hidden employment share as estimated by Center for the Study of Democracy (2016). Next, the average income tax rate was set to its statutory rate $\tau^y = 0.1$. Similarly, the tax rate on consumption is set to its value over the period, $\tau^c = 0.2$.

The TFP process is estimated from the detrended series of the Solow residuals by running an AR(1) regression. We proceed in a similar fashion for control of corruption, which is taken as our proxy for the institutional quality; we use the indices provided originally by Knack and Kiefer (1995), and then regularly updated by those authors. This index was chosen, as it reflects the closest the mechanism emphasized in the paper. In addition, the degree of persistence is comparable, while the variability is twice higher than that of the technology innovations.[13] Table 1 below summarizes the values of all model parameters used in the paper.

[12]This was part of the ideology of the totalitarian regime, which was in place until 1989.

[13]In a Technical Appendix, accompanying this paper, we present alternative specifications of the institutional quality, using political stability and government effectiveness. The results are qualitatively the same to the ones presented in the main body of the paper.

Table 1: Model Parameters

Parameter	Value	Definition	Method used
β	0.937	Discount factor	Calibrated
α	0.429	Capital Share	Data average
$1-\alpha$	0.571	Labor Share	Calibrated
σ	2.000	Curvature, utility function	Set/Literature
μ	0.333	Relative weight attached to leisure	Calibrated
δ	0.050	Depreciation rate on physical capital	Data average
η	0.600	Share of working hours used productively	Data average
τ^y	0.100	Average tax rate on income	Data average
τ^c	0.200	VAT/consumption tax rate	Data average
ρ_a	0.701	AR(1) persistence coefficient, TFP process	Estimated
σ_a	0.044	st. error, TFP process	Estimated
ρ_θ	0.787	AR(1) persistence coefficient, inst. quality process	Estimated
σ_θ	0.073	st. error, inst. quality process	Estimated

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. Next, the model sets consumption-to-output ratio equal to the empirical ratio, so this value is matched by construction; The investment and government purchases ratios, labor and capital shares, the after-tax return (where $\tilde{r} = (1-\tau^y)r - \delta$), all being free variables in the model, are also closely approximated, despite the closed-economy assumption and the absence of foreign trade sector.

Next, the model predicts that the magnitude of tax evasion relative to output is approximately 25.5 percent. This is very close to the European Commission (2014) figure of 25 % as well. Medina and Schneider (2017) also compute the value of the hidden economy to be $26.6-27.2$ percent of the official output over the period.

Table 2: Data Averages and Long-run Solution

Variable	Definition	Data	Model
y	Steady-state output	N/A	1.000
c/y	Consumption-to-output ratio	0.674	0.674
i/y	Investment-to-output ratio	0.201	0.175
g^c/y	Government cons-to-output ratio	0.159	0.151
$w\eta h/y$	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
A	Scale parameter of the production function	N/A	4.878
$\tilde{r}$	After-tax net return on capital	0.056	0.067
θ	Degree of tax evasion	0.250	0.255

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 solve the model numerically by log-linearizing the original equilibrium (non-linear) system of equations around the steady-state. This transformation produces a first-order system of stochastic linear difference equations. First, we study the dynamic behavior of model variables to an isolated shock to the total factor productivity process, to an isolated shock to institutional quality, 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: Technology Shock

This subsection documents the impulse responses of model variables to a 1% surprise innovation to technology. The impulse response functions (IRFs) are presented in Fig. 1 on the next page. First, output increases directly upon impact as a result of the improvement in technology. This expands the availability of resources in the economy, so uses of output - private consumption, investment, and government purchases 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 and start accumulating capital, and dedicates more time to productive activities. In turn, the increase in capital and labor input feeds back in output through the production function and that further adds to the positive effect of the technology shock. In the presence of rents, expressed in terms of private output,[14] also increases, which leads to more time spent on rent-seeking. Over time, as capital is being accumulated, its after-tax marginal product starts to decrease, which follows from the diminishing marginal product property built in the production function. A lower interest rate then lowers the households' incentives to save in the form of capital. Investment starts to decrease and returns to its old steady-state value. In turn, physical capital stock also returns to its steady-state, following a hump-shaped dynamics along its transition path. The rest of the model variables (except for consumption) also return to their old steady-states in a monotone fashion as the effect of the one-time surprise innovation in technology dies out.

5.1.1 Impulse Response Analysis: Institutional quality shock

In this section we simulate a *negative* one-percent innovation in θ_t, which corresponds to an *improvement* in institutional quality. In other words, that affects the degree to which corruption and rent-seeking are controlled.[15] The IRFs are presented in Fig. 2 on the next page. In particular, a decrease in θ_t has a two-fold effect: it (i) increases the returns to capital and labor, which increases labor supply and capital, which in turn increases output, bur also rent, and (ii) decreases the rent, expressed in terms of share of output. Overall, rent decreases, so there are two effects: one is greater participation, but the other is lower rent-seeking as well. In other words, higher η is like a higher endogenously-determined labor utilization rate.[16] Next, from the complementarity between productive hours and capital, investment will increase, and input productivity (wage and the interest rate) would also

[14] Note that in this scenario the degree of evasion, θ_t, is held fixed to its steady-state value.

[15] A lower θ_t can be thought of capturing, among other things, an improvement in the legal system, law and order, policing, supervision of financial institutions, and bankruptcy procedures. In turn, with better institutions the size of the rent, $\theta_t Y_t$, is lower.

[16] An important difference is that in "labor hoarding" models, *e.g.* Burnside and Eichenbaum (1993, 1996), an increase in utilization rate cannot be rationalized with increase in hours, as the two are substitutes in efficiency hours.

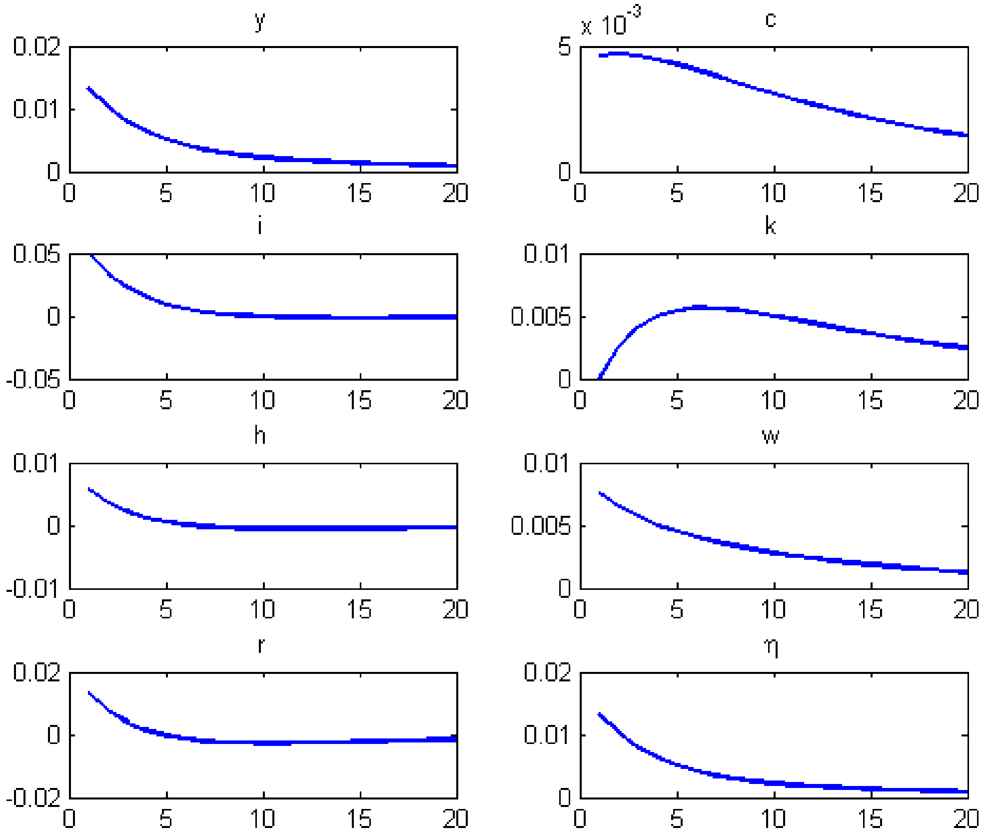

Figure 1: Impulse Responses to a 1% surprise innovation in technology

increase. As a result, income and output will increase, and consumption will grow as well.

Note that since θ_t indirectly affects productivity, it shares a lot of properties of the total factor productivity shock. A major advantage of our micro-founded setup, however, is to disentangle and distinguish between the two propagation channels, and break the "observational equivalence." In particular, the channel through which the institutional shock affects the economy is different. Furthermore, the magnitude of the responses of model variables is much larger. Therefore, not only is the institutional quality mechanism new, but it is also stronger, and more sophisticated than the effect of the classical total factor productivity shock.

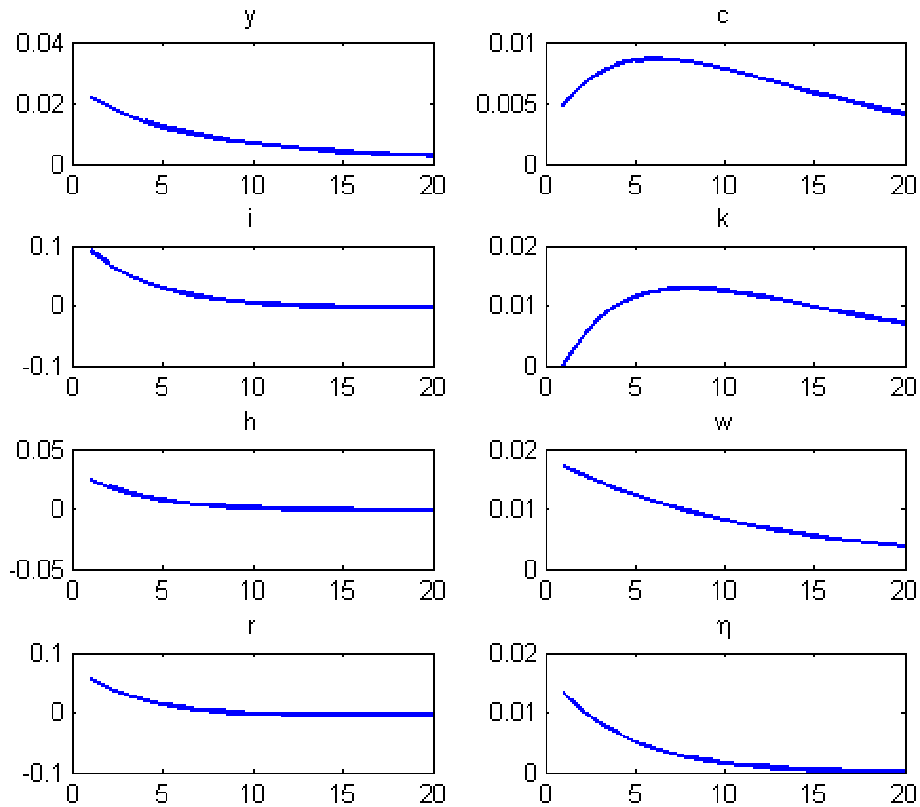

Figure 2: Impulse Responses to a 1% surprise innovation in corruption control

5.2 Simulation and moment-matching

As in Vasilev (2017b), we simulate 10,000 series of innovations for both TFP and institutional quality for the length of the data horizon.[17] We consider three specifications: Model I will feature only technology shocks, and θ will be held equal to its steady-state value; In contrast, Model II shuts down any fluctuations in A_t, so the only source of economic fluctuations are innovations in institutional quality. Finally, Model III is a setup with both technology and institutional shocks, which we refer to as the "full model." The combined effect depends on the relative persistence and standard deviation of the shocks. In our calibration, the persistence of the TFP process, and the one featured by "control of corruption" process are roughly equal, while the innovations to the latter vary almost twice more. Table 3

[17]Both empirical and model simulated data is detrended using the Hodrick-Prescott (1980) filter.

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 annual frequency. Similar to Vasilev (2016, 2017b, 2017c), the setups overestimate the relative volatility of consumption and investment, but are still qualitative consistent with the stylized facts that consumption varies less than output, and investment varies more than output. By construction, in all versions of the model government purchases vary as much as output. With the introduction of endogenous rent-seeking time,

Table 3: Business Cycle Moments

Statistic	Data value	Model I: Tech. shocks only $\rho_a, \sigma_a \neq 0$ $\rho_\theta, \sigma_\theta = 0$	Model II: Inst. shocks only $\rho_a, \sigma_a = 0$ $\rho_\theta, \sigma_\theta \neq 0$	Model III: Full model/both shocks $\rho_a, \sigma_a \neq 0$ $\rho_\theta, \sigma_\theta \neq 0$
σ_c/σ_y	0.55	0.83	0.82	0.84
σ_i/σ_y	1.77	2.35	2.51	2.38
σ_g/σ_y	1.21	1.00	1.00	1.00
σ_h/σ_y	0.63	0.24	0.66	0.33
σ_w/σ_y	0.83	0.87	1.04	0.90
$\sigma_{y/h}/\sigma_y$	0.86	0.87	1.04	0.90
$corr(c, y)$	0.85	0.92	0.92	0.92
$corr(i, y)$	0.61	0.86	0.87	0.86
$corr(g, y)$	0.31	1.00	1.00	1.00
$corr(h, y)$	0.49	0.58	0.75	0.56
$corr(w, y)$	-0.01	0.97	0.98	0.97

the volatility of working hours increases and that brings variability of hours closer to that in data in the presence of institutional shocks. Wage variability is close to that observed in data, a bit higher in the setup with institutional shocks, and in the combined model.Next, in terms of contemporaneous correlations, all models systematically over-predict the pro-cyclicality of the main aggregate variables - private consumption, investment, and government purchases. This, however, is a common limitation of this class of market-clearing models. With respect to wages, the model predicts strong cyclicality, while wages in data are acyclical. This shortcoming is also well-known in the neoclassical literature and an artifact of the wage being equal to the labor productivity in the model.

5.3 Auto- and cross-correlation

This subsection discusses the auto-(ACFs) and cross-correlation functions (CCFs) of the major model variables. The coefficients of empirical ACFs, obtained from an unrestricted VAR(1), are presented in Table 4 on the next page against the averaged simulated AFCs. For the sake of brevity, we present only results for the full model with both shocks at work, i.e, Model III.[18]

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, household consumption, and hours are relatively well-approximated by the model. The persistence of hours is not well-described by the model dynamics. Overall, both models generates too much persistence in output and employment, and is subject to the criticism in Nelson and Plosser (1992), Cogley and Nason (1995) and Rotemberg and Woodford (1996b). All those authors argue that the RBC class of models do not have a strong internal propagation mechanism besides the strong persistence in the TFP process. In this class of models, *e.g.* Vasilev (2009) for Bulgaria, and in the current one, labor market is modeled in the Walrasian market-clearing spirit, and there is not involuntary unemployment.

Next, we compare the dynamic correlations of hours and wages from the model against the empirical estimates. As seen from Table 5 above, over the business cycle, in data labor productivity leads hours. Unfortunately, the model with institutional quality is not able to account for this fact, as both the institutional and the technology shocks generate only a contemporaneous effect between employment and labor productivity. Indeed, this is what we see in Table 5: the highest value of the correlation is the contemporaneous one.

[18]Models I, II and III are all very close to one another. Following Canova (2007), this comparison is used as a goodness-of-fit measure.

Table 4: Autocorrelations for Bulgarian data and the model economy

		k			
Method	Statistic	0	1	2	3
Data	$corr(h_t, h_{t-k})$	1.000	0.484	0.009	0.352
Full Model	$corr(h_t, h_{t-k})$	1.000	0.954	0.888	0.829
	(s.e.)	(0.000)	(0.028)	(0.054)	(0.078)
Data	$corr(y_t, y_{t-k})$	1.000	0.810	0.663	0.479
Full Model	$corr(y_t, y_{t-k})$	1.000	0.957	0.906	0.847
	(s.e.)	(0.000)	(0.025)	(0.048)	(0.069)
Data	$corr(a_t, a_{t-k})$	1.000	0.702	0.449	0.277
Full Model	$corr(a_t, a_{t-k})$	1.000	0.959	0.901	0.838
	(s.e.)	(0.000)	(0.027)	(0.052)	(0.075)
Data	$corr(c_t, c_{t-k})$	1.000	0.971	0.952	0.913
Full Model	$corr(c_t, c_{t-k})$	1.000	0.959	0.901	0.838
	(s.e.)	(0.000)	(0.027)	(0.052)	(0.075)
Data	$corr(i_t, i_{t-k})$	1.000	0.810	0.722	0.594
Full Model	$corr(i_t, i_{t-k})$	1.000	0.954	0.898	0.833
	(s.e.)	(0.000)	(0.028)	(0.053)	(0.077)

Table 5: Dynamic correlations for Bulgarian data and the model economy

		k						
Method	Statistic	-3	-2	-1	0	1	2	3
Data	$corr(h_t, (y/h)_{t-k})$	-0.342	-0.363	-0.187	-0.144	0.475	0.470	0.346
Full model	$corr(h_t, (y/h)_{t-k})$	0.038	0.046	0.056	0.499	0.106	0.034	-0.017
	(s.e.)	(0.348)	(0.304)	(0.252)	(0.294)	(0.234)	(0.266)	(0.301)
Data	$corr(h_t, w_{t-k})$	0.355	0.452	0.447	0.328	-0.040	-0.390	-0.57
Full model	$corr(h_t, w_{t-k})$	0.038	0.046	0.056	0.499	0.106	0.034	-0.017
	(s.e.)	(0.348)	(0.304)	(0.252)	(0.294)	(0.234)	(0.266)	(0.301)

6 Conclusions

This paper takes an otherwise standard real-business-cycle setup with government sector, and augments it with an output-expropriation mechanism and shocks to institutional quality to study business cycle fluctuations. The extraction decision is endogenous: households can use their time either productively, or engage in extraction activities. Stronger institutions decrease the size of the rent available for capture, and suppress opportunistic behavior. As a test case, the model is calibrated to Bulgaria after the introduction of the currency board (1999-2018). An interesting result obtained from the model setup is that on average, the estimated size of evaded resources is approximately one-fourth of output, which is very close to the estimates of the unofficial economy share, *e.g.* European Commission (2014) and Medina and Schneider (2017). In addition, the shocks to institutional quality generate business cycles of the same magnitude as in data and suggest that political economy factors might be the major driving force behind economic fluctuations in Bulgaria. Therefore, allowing for factors other than technology shocks to explain business cycle movements contributes to the understanding of how the Bulgarian economy works.

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