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**Article — Accepted Manuscript (Postprint)**

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The IUP Journal of Applied Finance

*Suggested Citation:* Vasilev, Aleksandar (2021) : Are credit shocks quantitatively important for the propagation of aggregate fluctuations in Bulgaria (1999-2018)?, The IUP Journal of Applied Finance, ISSN 0972-5105, IUP Publications, Hyderabad, Telangana, India, Vol. 27, Iss. 3, pp. 5-20, [https://www.iupindia.in/Applied\\_Finance.asp](https://www.iupindia.in/Applied_Finance.asp)

This Version is available at:

<https://hdl.handle.net/10419/243047>

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# Are credit shocks quantitatively important for the propagation of aggregate fluctuations in Bulgaria (1999-2018)?

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August 31, 2020

## Abstract

We augment an otherwise standard business cycle model with a richer government sector, and add a stochastic costly credit production as in Benk at al. (2005), and a modified cash in advance (CIA) considerations. In particular, the cash in advance constraint of Cole (2020) is extended to include private investment and government consumption, and allows an endogenous proportion of total expenditure to be done using credit. This specification is then calibrated to Bulgarian data after the introduction of the currency board (1999-2018). The costly credit production mechanism adds little in explaining business cycle fluctuations. Credit shocks by themselves are an unlikely candidate to drive the business cycle. In addition, the modified CIA constraint produces a transmission mechanism that generates too much investment volatility, and too little variability in hours and wages in the model.

**Keywords:** business cycles, modified cash-in-advance (CIA) constraint, stochastic credit production, time cost, Bulgaria

*JEL Classification:* E32

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# 1 Introduction and Motivation

It is a well-known fact, *e.g.* Prescott (1986), that the aggregate fluctuations produced by the standard real-business-cycle (RBC) model are entirely driven by highly-persistent innovations to the total factor productivity part of the aggregate production functions (and labeled as "technological shocks"). After the recent financial crisis, however, the focus has shifted to other potential sources of shocks that could also influence the business cycle, namely financial shocks. In this paper we try to contribute to this strand of research, by focusing on the case of Bulgaria.

Why Bulgaria? Bulgaria is a former transition economy, and as of 2007 - an EU member state. However, Bulgaria is the poorest EU member, as it is still developing. During the period 1996-97, it suffered a major banking and financial crisis. Since 1997, Bulgaria introduced a currency board arrangement, which is an extreme form of a fixed exchange rate to the German mark, and later - to the Euro. Bulgaria also privatized essentially its entire banking system. The banking system was thus quickly stabilized, and the rate of inflation converged to the EU-average inflation rate.<sup>1</sup> Therefore, the Bulgarian economy since 1999 is a good testing ground for a monetary model with credit, and financial shocks. Such shocks might be potentially important candidates for driving some of the fluctuations in the major macroeconomic variables.

The presence of a currency board, or the openness of the economy do not constitute important limitations of the parsimonious model presented in this paper. The focus is on the role of money and credit in the domestic economy. In the model, exchange credit will be a partial substitute for money. More specifically, the representative household will be both a user of money, as well as a producer of credit ("banker"). It will use "banking time" in a similar fashion to shopping time models. The production of credit will be subject to financial sector productivity innovations, which will be labelled "credit shocks" as in Gillman and

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<sup>1</sup>The currency board in place means that the government cannot "print money" freely. In particular, it has no incentive to create inflation for seigniorage/tax revenue purposes.

Kejak (2004), Gillman and Kejak (2005), Benk et al. (2005).<sup>2</sup>

In order to avoid running into the problem of so-called "observational equivalence" - which produces an outcome when two or more models of substantially different structure may explain equally well certain stylized facts - economists need to justify the inclusion of alternative propagation mechanisms. Therefore, in this paper we base our modeling approach on a particular empirical regularities in Bulgaria, namely that Bulgarian financial system is loan-based, and that households predominantly use cash for purchases, which is the norm in the period following the introduction of the currency board arrangement (1999-2018). We adopt the modelling approach followed by Cole (2020) to incorporate a modified cash-in-advance (CIA) constraint in RBC models, as well as endogeneize the share of cash by allowing for costly credit production as in Benk et al. (2005) in order to investigate the quantitative effect of money, and credit production shocks in particular, on business cycle fluctuations in aggregate variables in Bulgaria, and whether it is able to address the "labor market puzzle," and validate certain labor market facts.<sup>3</sup>

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

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<sup>2</sup>Lucas (2000) acknowledges that such a modelling approach is a promising research venue. Other recent contributions on the topic are Espino and Hintermaier (2004), who extended Kocherlakota (2000), Kiyotaki and Moore (1997) and Kiyotaki. Our model is consistent with those setups, as over time the household will accumulate more physical capital, which increases the collateral and acts like relaxing the borrowing constraint.

<sup>3</sup>In the standard RBC model the fluctuations in employment are due to movements in labor supply. In other words, households increase hours in the face of a raise in the return on labor, the wage, driven by shocks to technology. Instead, if an RBC model is to fit data better along the labor market dimension, even for a small economy like Bulgaria, shocks that work on labor demand and shift it around would be much better candidates to explain the observed fluctuations in the wage rate, aggregate hours and employment.

## 2 Model Setup

There is a representative household, which derives utility out of consumption and leisure. The time available to households can be spent in productive use, as leisure, or to produce credit. The households use cash for the majority of their purchases, with the share of cash being endogenous. 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. The monetary authority follows an endogenous money supply rule, and redistributes all seigniorage back to the household. On the production side, there is a representative firm, which hires labor and capital to produce a homogeneous final good, which could be used for consumption, investment, or government purchases.

### 2.1 Household problem

Each household maximizes expected discounted utility, which is of the form

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t + \phi \ln x_t \right\}, \quad (1)$$

where  $E_0$  is the expectation operation conditional on information available as of  $t = 0$ ,  $0 < \beta < 1$  is the discount factor,  $c_t$  is the household consumption in period  $t$ ,  $x_t$  is leisure, and parameter  $\phi > 0$  is the weight attached to disutility of work.

The household starts with a positive endowment of physical capital,  $k_0$ , in period 0, which is rented to the firm at the nominal rental rate  $R_t$ , that is, before-tax capital income equals  $R_t k_t$ . Therefore, each household can decide to invest in capital to augment the capital stock, which evolves according to the following law of motion:

$$k_{t+1} = i_t + (1 - \delta)k_t, \quad (2)$$

where  $0 < \delta < 1$  is the depreciation rate of physical capital.

In addition to the rental income, the household owns the firm, and thus has a legal claim to the firm's nominal profit,  $\Pi_t$ . Lastly, the household works a certain number of hours, which are remunerated at the nominal wage rate  $W_t$ , producing a total nominal labor income of

$W_t h_t$  in period  $t$ .

Total time endowment, normalized to unity, can be used to work, to produce credit - or "banking time" ( $l_{Ft}$ ), or enjoyed as leisure, or

$$h_t + l_{Ft} + x_t = 1 \quad (3)$$

Real money balances are needed to purchase output, hence the households face the following augmented cash-in-advance constraint

$$\kappa_t[(1 + \tau^c)c_t + k_{t+1} - (1 - \delta)k_t + g_t^c] = \frac{M_t}{P_t} = m_t, \quad (4)$$

where  $0 < \kappa_t < 1$  reflects the fact that only part of expenditure is done using cash, while the rest is purchased using credit.<sup>4</sup> In addition, credit is costly to produce, and as in Gillman et al. (1997), Benk et al. (2005), and Gillman and Kejak (2005), total time cost is proportional to consumption, or

$$(1 - \kappa_t)c_t = A_F v_t \left( \frac{l_{Ft}}{c_t} \right)^\gamma c_t \quad (5)$$

$$1 - \kappa_t = A_F v_t \left( \frac{l_{Ft}}{c_t} \right)^\gamma, \quad (6)$$

with  $A_F > 0$  the scale parameter of the credit production technology, and  $\gamma \in (0, 1)$  reflecting the degrees to scale of the credit production technology.

Next, the budget constraint of the aggregate household, expressed in real terms, is then

$$(1 + \tau^c)c_t + k_{t+1} - (1 - \delta)k_t + \frac{M_{t+1}}{P_t} \frac{P_{t+1}}{P_{t+1}} = (1 - \tau^y) \left[ w_t [1 - x_t - \left( \frac{1 - \kappa_t}{A_F v_t} \right)^{1/\gamma}] + r_t k_t \right] + \frac{M_t}{P_t} + g_t^t + \frac{\Pi_t}{P_t}, \quad (7)$$

where  $\tau^c$  is the tax rate on final consumption,  $\tau^y$  is the proportional rate on labor and capital income, and  $P_t$  is the aggregate price level.  $M_t$  denote the nominal quantities of money holdings in period  $t$ . Money stock is treated like a consumption good, it stores wealth over time. That is why real money balances in period  $t$  are  $m_t = M_t/P_t$  in period  $t + 1$  only buy

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<sup>4</sup>This modelling choice generates a non-standard money demand, with an endogenous and time-varying money velocity.

$M_t/P_{t+1}$  (next period purchasing power). Similarly,  $w_t = W_t/P_t$ , and  $r_t = R_t/P_t$  are the real wage and the real interest rate.

Next, we set up the Lagrangean of the household's problem:

$$L = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t + \phi \ln x_t - \lambda_t \left[ (1 + \tau^c)c_t + k_{t+1} - (1 - \delta)k_t + m_{t+1}(1 + \pi_{t+1}) \right. \right. \\ \left. \left. - (1 - \tau^y) \left[ w_t \left[ 1 - x_t - \left( \frac{1 - a_t}{A_F v_t} \right)^{1/\gamma} \right] + r_t k_t \right] - m_t - g_t - \frac{\Pi_t}{P_t} \right] \right. \\ \left. - \mu_t \left[ \kappa_t [(1 + \tau^c)c_t + k_{t+1} - (1 - \delta)k_t + g_t^c] - m_t \right] \right\} \quad (8)$$

The first-order optimality conditions (FOCs) are as follows:

$$c_t : \frac{1}{c_t} = (1 + \tau^c) \left[ \lambda_t + \kappa_t \mu_t \right] \quad (9)$$

$$x_t : \frac{\phi}{x_t} = \lambda_t (1 - \tau^y) w_t, \quad (10)$$

$$\kappa_t : \mu_t [(1 + \tau^c)c_t + k_{t+1} - (1 - \delta)k_t + g_t^c] = \lambda_t (1 - \tau^y) w_t \frac{1}{\gamma} \left( \frac{1 - \kappa_t}{A_F} \right)^{1/\gamma} v_t^{\frac{1}{\gamma} - 1} \quad (11)$$

$$k_{t+1} : \lambda_t + \kappa_t \mu_t = \beta E_t \left[ \lambda_{t+1} [1 - \delta + (1 - \tau^y)r_{t+1}] + \mu_{t+1} a_t (1 - \delta) \right], \quad (12)$$

$$m_{t+1} : \lambda_t = \beta E_t \left[ \frac{1}{1 + \pi_{t+1}} (\lambda_{t+1} + \mu_{t+1}) \right], \quad (13)$$

where  $\pi_{t+1}$  is the inflation rate between periods  $t$  and  $t + 1$ . Lastly, the boundary (transversality) conditions for capital, and real money balances are as follows:

$$TVC_k : \lim_{t \rightarrow \infty} \beta^t \lambda_t k_{t+1} = 0 \quad (14)$$

$$TVC_m : \lim_{t \rightarrow \infty} \beta^t \lambda_t m_{t+1} = 0 \quad (15)$$

The interpretation of the optimality conditions is standard. In the first, the household equates the marginal utility of consumption, to the VAT adjusted shadow price of wealth and the CIA constraint. The second FOC determines optimal number of hours worked, by balancing at the margin the cost and benefit from working, and reflecting the imputed price of time cost of costly credit production. Similarly, the third equation determines the optimal share of cash, by balancing the benefit and costs of using cash, at the margin. The

remaining equations from the original FOCs are standard: for example, the Euler equation for capital stock describes how capital is allocated across any adjacent periods in order to maximize household's utility. Similarly, the next first-order condition describes the rule for optimal real money balances. The transversality conditions (TVCs) for real cash holdings, and physical capital are imposed to rule out explosive solutions.

## 2.2 Stand-in firm's problem

There is a stand-in firm in the economy, which uses homogeneous capital and labor to produce a final good, which can be used for consumption, investment, or government purchases, through the following production function:

$$y_t = A_t k_t^\alpha h_t^{1-\alpha}, \quad (16)$$

where  $A_t$  denotes the level of total factor productivity in period  $t$ ,  $h_t$  are total hours used, and  $\alpha$  and  $1 - \alpha$  are the share of capital and labor, respectively. The firm's problem, expressed in real terms, is to

$$\max_{(k_t, h_t) \geq 0} A_t k_t^\alpha h_t^{1-\alpha} - r_t k_t - w_t h_t \quad (17)$$

The first-order optimality conditions determining optimal capital, and labor use are

$$k_t : \alpha \frac{y_t}{k_t} = r_t, \quad (18)$$

$$h_t : (1 - \alpha) \frac{y_t}{h_t} = w_t. \quad (19)$$

Given the results above, it follows that profit is zero in all periods. Also, for consistency,  $h_t = 1 - x_t - (1 - a_t)T_t c_t, \forall t$ .

## 2.3 Monetary Authority

Money in the model is a means of payment that is costless to produce. In this paper the monetary authority (central bank) supplies the money aggregate,  $M_t$ , endogenously. In other words, the money supply will respond to the demand for currency for transaction purposes. All money created (seigniorage) in period  $t$  is then distributed to the government, and then to the households in a lump-sum fashion

$$M_{t+1} - M_t = S_t, \quad (20)$$



where  $S_t$  is the lump-sum nominal transfer (seigniorage) to the household. In the government budget constraint below, we will assume that the central bank distributes the seigniorage to the Ministry of Finance, which in turn passes it to the household as part of the overall real government lump-sum transfer,  $g_t^t$ .

## 2.4 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 government purchases and government transfers. The government budget constraint, expressed in real terms, is as follows:

$$\tau^c c_t + \tau^y (w_t h_t + r_t k_t) = g_t^t + g_t^c \quad (21)$$

Tax rates and government consumption-to-output ratio would be chosen to match the average share in data, and government transfers (inclusive of the seigniorage transfer) would be determined residually.

## 2.5 Stochastic process

Total factor productivity,  $A_t$ , is assumed to follow AR(1) processes in logs, in particular

$$\ln A_{t+1} = (1 - \rho_a) \ln A_0 + \rho_a \ln A_t + \epsilon_{t+1}^a,$$

where  $A_0 > 0$  is steady-state level of the total factor productivity process,  $0 < \rho_a < 1$  is the first-order autoregressive persistence parameter and  $\epsilon_t^a \sim iidN(0, \sigma_a^2)$  are random shocks to the total factor productivity progress. Hence, the innovations  $\epsilon_t^a$  represent unexpected changes in the total factor productivity process.

Similarly, credit productivity,  $v_t$ , is also assumed to follow AR(1) processes in logs, in particular

$$\ln v_{t+1} = (1 - \rho_v) \ln v_0 + \rho_v \ln v_t + \epsilon_{t+1}^v,$$

where  $v_0 > 0$  is steady-state level of the credit parameter,  $0 < \rho_v < 1$  is the first-order autoregressive persistence parameter and  $\epsilon_t^v \sim iidN(0, \sigma_v^2)$  are random shocks to the credit productivity progress. Hence, the innovations  $\epsilon_t^v$  represent unexpected changes in the credit productivity process.

## 2.6 Dynamic Competitive Equilibrium (DCE)

Given the stochastic processes  $\{A_t, v_t\}_{t=0}^{\infty}$ , average tax rates  $\{\tau^c, \tau^y\}$ , endowments  $(k_0, m_0)$ , the decentralized dynamic competitive equilibrium is a list of sequences  $\{c_t, i_t, k_t, h_t, m_t, \kappa_t, x_t\}_{t=0}^{\infty}$ , a sequence of government purchases and transfers  $\{g_t^c, g_t^t\}_{t=0}^{\infty}$ , and real input prices  $\{w_t, r_t\}_{t=0}^{\infty}$  such that (i) the household maximizes its utility function subject to its budget constraint, and the CIA constraint; (ii) the representative firm maximizes profit; (iii) government budget constraint is balanced in each period; (iv) all markets clear.

## 3 Data and Model Calibration

To calibrate the model to Bulgarian data, we will focus on the period after the introduction of the currency board (1999-2018). Annual data on output, consumption and investment was collected from National Statistical Institute (2020), while the real interest rate is taken from Bulgarian National Bank Statistical Database (2020). The calibration strategy described in this section follows a long-established tradition in modern macroeconomics: first, the discount factor,  $\beta = 0.982$ , as in Vasilev (2017a), is set to match the steady-state capital-to-output ratio in Bulgaria,  $k/y = 3.491$ . The labor share parameter,  $\alpha = 0.429$ , was obtained from Vasilev (2017b) as the average value of labor income in aggregate output over the period 1999-2014.

The relative weights attached to the utility out of leisure in the household's utility function,  $\phi$ , is calibrated to match the fact that in steady-state consumers would supply one-third of their time endowment to working. The CIA parameter  $\kappa = 0.85$  is calibrated to match the share of purchases made using cash. In other words, the money in the model corresponds to M2 money aggregate, and  $M2/Y = 0.848$  on average over the period 1999-2018. As in Benk et al. (2005),  $\gamma = 0.21$ .<sup>5</sup> The banking time,  $l_F = 0.025$ , will be set equal to the proportion of people working in the finance, insurance and real estate industry, which in turn will determine the scale parameter of the credit production function,  $A_F$ .

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<sup>5</sup>In addition, values of  $\gamma \in (0, 0.5)$  generate a convex, upward-sloping, marginal cost curve, which is in line with empirical evidence, e.g. Gillman and Kejak (2005). A rising marginal cost of credit output per consumption is also used in Gillman (1993).

Next, the average depreciation rate of physical capital in Bulgaria,  $\delta = 0.05$ , was taken from Vasilev (2015). It was estimated as the average depreciation rate over the period 1999-2014. Similarly, the average income tax rate was set to  $\tau^y = 0.1$ , and the tax rate on consumption is set to its value over the period,  $\tau^c = 0.2$ . Lastly, as in Vasilev (2017c), the process followed by total factor productivity is estimated from the detrended Solow residual series by running an AR(1) regression and saving the residuals. Given the lack of data, we assume the same moments for the credit shock. Table 1 below summarizes the values of all model parameters used in the paper.

Table 1: Model Parameters

Parameter	Value	Description	Method
$\beta$	0.982	Discount factor	Calibrated
$\alpha$	0.429	Capital Share	Data average
$\delta$	0.050	Depreciation rate on physical capital	Data average
$\phi$	0.853	Parameter, disutility of work	Calibrated
$\gamma$	0.210	Returns to scale, credit production	Set
$\tau^c$	0.200	VAT/consumption tax rate	Data average
$\tau^y$	0.100	Average tax rate on income	Data average
$\kappa$	0.850	Share of purchases made using cash	Data average
$\rho_a$	0.701	AR(1) parameter, total factor productivity	Estimated
$\rho_v$	0.701	AR(1) parameter, credit process	Set
$\sigma_a$	0.044	st.dev, total factor productivity	Estimated
$\sigma_v$	0.044	st.dev, credit process	Set

## 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 on the next page. (We approximate the economy around zero inflation.) The model matches consumption-to-output ratio by construction; The investment

and government purchases ratios are also closely approximated. 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. Lastly, the after-tax return, net of depreciation,  $\tilde{r} = (1 - \tau^y)r - \delta$ , is also very closely captured by the model.

Table 2: Data Averages and Long-run Solution

Variable	Description	Data	Model
$y$	Steady-state output	N/A	0.568
$c/y$	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
$wh/y$	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
$\tilde{r}$	After-tax net return on capital	0.056	0.057

## 5 Out of steady-state model dynamics

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

## 5.1 Impulse Response Analysis

This subsection documents the impulse responses of model variables to a 1% surprise innovation to technology. The impulse response function (IRFs) to the technology-, and credit shocks, are presented in Fig. 1 and Fig. 2, respectively.

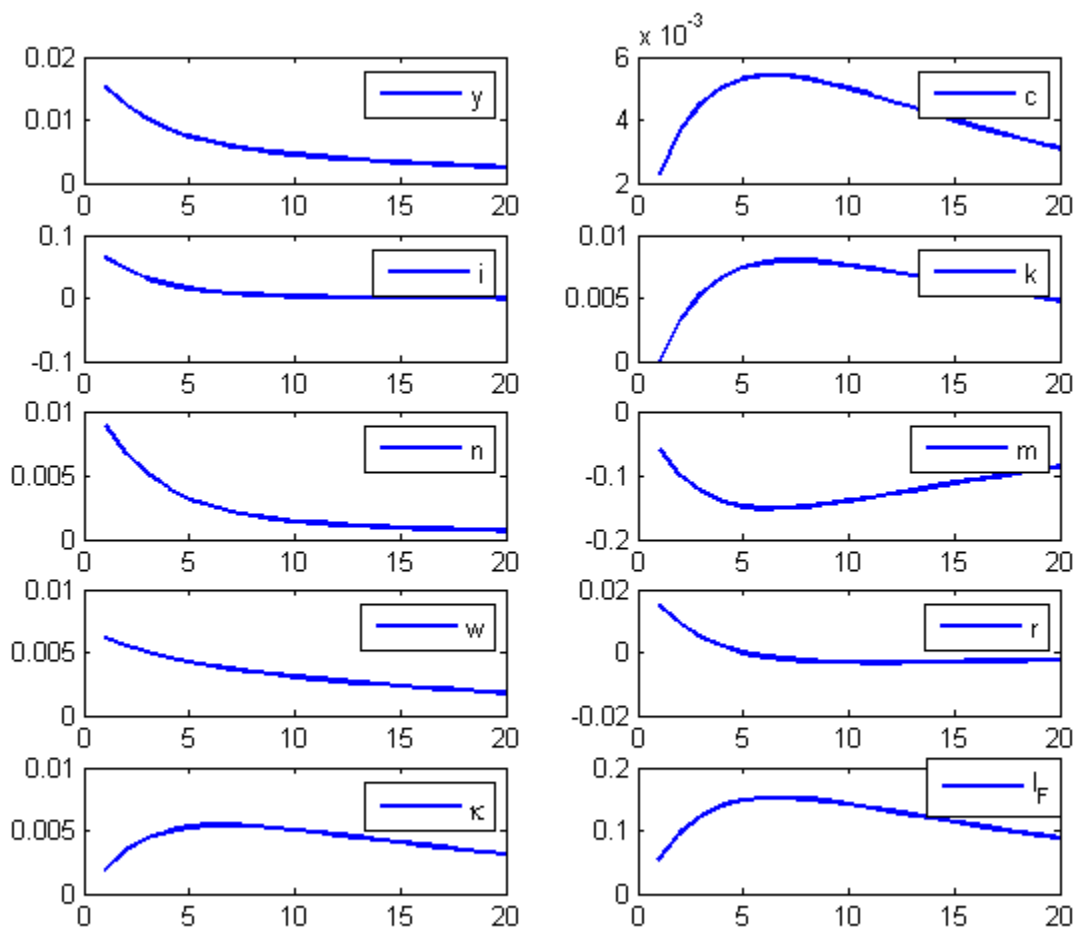


Figure 1: Impulse Responses to a 1% surprise innovation in technology

As a result of the one-time unexpected positive shock to total factor productivity, output increases directly upon impact of the shock. This expands the availability of resources in the economy, so uses of output - consumption, investment, and government consumption also increase contemporaneously. At the same time, the jump in total factor productivity increases

the after-tax return on the two factors of production, labor and capital. The representative households then respond to the incentives contained in prices and start accumulating physical capital, and supplies more hours worked. In turn, the increase in capital input feeds back in output through the production function and that further adds to the positive effect of the technology shock. In the labor market, the wage rate increases, and the household increases its hours worked. In turn, the increase in total hours further increases output, again indirectly.

Over time, as capital is being accumulated, its after-tax marginal product starts to decrease, which lowers the households' incentives to save. As a result, physical capital stock eventually returns to its steady-state, and exhibits a hump-shaped dynamics over its transition path. The rest of the model variables return to their old steady-states in a monotone fashion as the effect of the one-time surprise innovation in technology dies out. On the monetary side, real money balances follows the path of output and consumption, combined. This dynamics follows directly from modified the CIA constraint. Similarly, the transition path of banking time,  $l_F$ , follows the path of consumption, as the time cost is proportional to that component of output. Finally, the share of cash is only very slightly pro-cyclical, as higher output requires the use of more cash in the model setup. Over the cycle, banking time is more expensive, and thus the household supplies more hours in the private sector.

Next, the response to credit shocks is depicted in Fig. 2 below. A positive credit shock makes credit production less costly, and thus decreases banking time,  $l_F$ .

In turn, cheaper credit decreases the need for cash, hence  $\kappa$  decreases as well upon impact of the shock. Net, from the marginal rate of substitution, given that leisure increases, consumption has to increase as well to preserve the balance. On the monetary side, real money balances follows the path of output and consumption, combined. This dynamics follows directly from modified the CIA constraint. However, the quantitative effect of this shock is tiny, especially if we focus on the major aggregate variables. Therefore, credit shocks in this setup are not a good candidate for business cycle propagation mechanism.

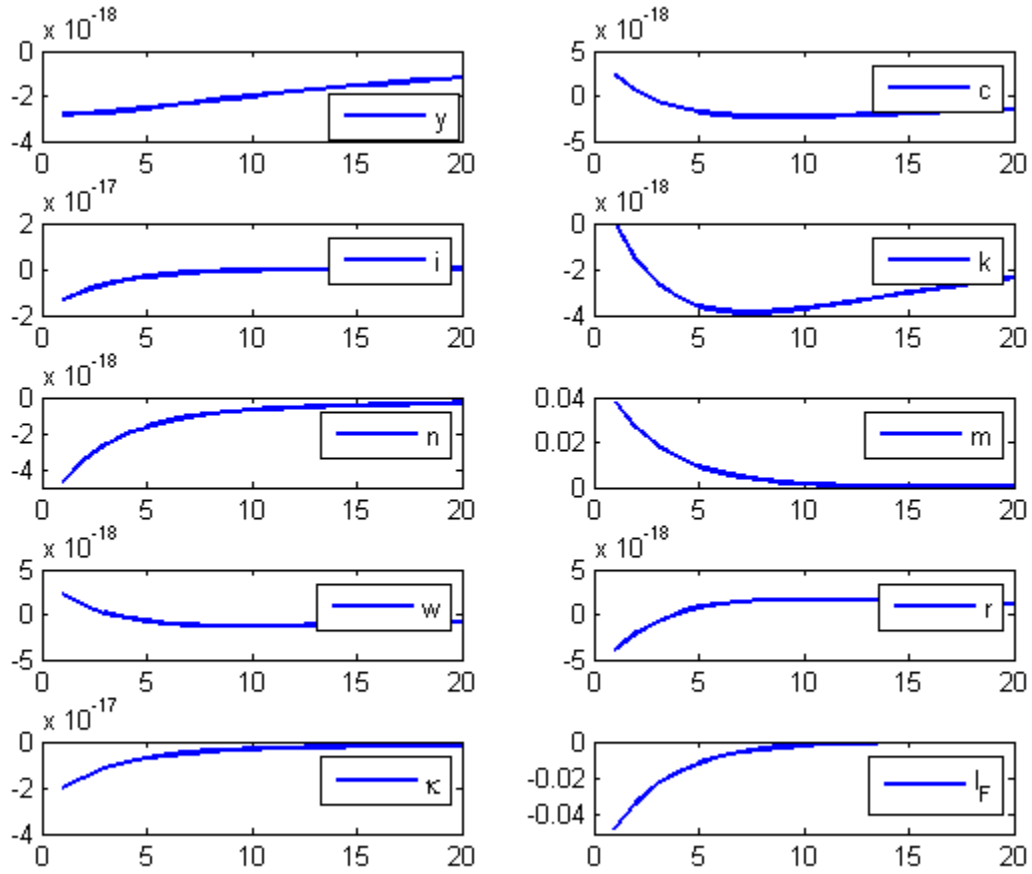


Figure 2: Impulse Responses to a 1% surprise innovation in credit production

## 5.2 Simulation and moment-matching

We will now simulate the model 10,000 times for the length of the data horizon. Both empirical and model simulated data is detrended using the Hodrick-Prescott (1980) filter. Table 3 on the next page summarizes the second moments of data (relative volatilities to output, and contemporaneous correlations with output) versus the same moments computed from the model-simulated data at annual frequency. To minimize the sample error, the simulated moments are averaged out over the computer-generated draws. We simulate the model with each shock working separately, as well as the setup with both shocks combined. As evident from Table 3, the credit shocks add little in terms of moment volatility. In what is to follow, we will focus on the case with both shocks at work. This model matches quite well the

absolute volatility of output. However, the model substantially overestimates the variability in both consumption, and investment. Still, the model is qualitatively consistent with the stylized fact that consumption is less volatile than output, and investment is more volatile than output. By construction, government spending in the model varies as much as in data. With respect to the labor market variables, the variability of employment and wages predicted by the model is lower than in data, which could be explained by the presence of costly credit production, which requires banking time.

Table 3: Business Cycle Moments

	Data	Model (both shocks)	Model (tech. shocks only)	Model (credit shocks only)
$\sigma_y$	0.05	0.05	0.05	0.05
$\sigma_c/\sigma_y$	0.55	0.71	0.73	1.16
$\sigma_i/\sigma_y$	1.77	3.04	3.05	7.35
$\sigma_g/\sigma_y$	1.21	1.00	1.00	1.00
$\sigma_h/\sigma_y$	0.63	0.48	0.48	0.46
$\sigma_w/\sigma_y$	0.83	0.55	0.55	0.23
$\sigma_{y/h}/\sigma_y$	0.86	0.55	0.55	0.23
$corr(c, y)$	0.85	0.67	0.62	0.02
$corr(i, y)$	0.61	0.69	0.72	0.02
$corr(g, y)$	0.31	1.00	1.00	1.00
$corr(h, y)$	0.49	0.90	0.91	0.02
$corr(w, y)$	-0.01	0.93	0.92	-0.02
$corr(u, y)$	-0.47	-0.90	-0.91	-0.02
$corr(h, y/h)$	-0.14	0.76	0.73	-1.00

Next, in terms of contemporaneous correlations, the model slightly over-predicts the procyclicality of the main aggregate variables - investment and government consumption, while underpredicting the correlation of consumption. With respect to wages, the model predicts strong cyclicity, while wages in data are acyclical. All those, however, is a common limitation of this class of general-equilibrium models.



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

### 5.3 Auto- and cross-correlation

This subsection discusses the auto-(ACFs) and cross-correlation functions (CCFs) of the major model variables. The coefficients empirical ACFs and CCFs at different leads and lags are presented in Table 4 against the simulated AFCs and CCFs. Following Canova (2007), this comparison is used as a goodness-of-fit measure. For the sake of brevity, we only present the results for the setup with both shocks at work. As seen from Table 4 below, the model compares well vis-a-vis data. Empirical ACFs for consumption and total factor productivity are slightly outside the confidence band predicted by the model, while the ACFs for output and investment are well-approximated by the model.

The persistence of labor market variables are also well-described by the model dynamics: Overall, the model with CIA constraint and costly credit production generates the right persistence in model variables, and is able to respond to the criticism in Nelson and Plosser (1992), Cogley and Nason (1995) and Rotemberg and Woodford (1996), who argue that the RBC class of models do not have a strong internal propagation mechanism besides the strong persistence in the TFP process.

Next, as seen from Table 5 on the next page, over the business cycle, in data labor productivity leads employment. The model with CIA constraint and costly credit, however, cannot account for this fact. In this model, as well as in the standard RBC model, a technology shock can be regarded as a factor shifting the labor demand curve, while holding the labor supply curve constant. Therefore, the effect between employment and labor productivity is only a contemporaneous one. Still, the model with a CIA constraint and costly credit production is a clear improvement over the real setup with perfectly-competitive labor

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
Model	$corr(h_t, h_{t-k})$	1.000	0.816	0.628	0.443
	(s.e.)	(0.000)	(0.035)	(0.064)	(0.086)
Data	$corr(y_t, y_{t-k})$	1.000	0.810	0.663	0.479
Model	$corr(y_t, y_{t-k})$	1.000	0.815	0.627	0.443
	(s.e.)	(0.000)	(0.036)	(0.064)	(0.085)
Data	$corr(a_t, a_{t-k})$	1.000	0.702	0.449	0.277
Model	$corr(a_t, a_{t-k})$	1.000	0.817	0.629	0.442
	(s.e.)	(0.000)	(0.034)	(0.062)	(0.086)
Data	$corr(c_t, c_{t-k})$	1.000	0.971	0.952	0.913
Model	$corr(c_t, c_{t-k})$	1.000	0.817	0.633	0.452
	(s.e.)	(0.000)	(0.031)	(0.056)	(0.076)
Data	$corr(i_t, i_{t-k})$	1.000	0.810	0.722	0.594
Model	$corr(i_t, i_{t-k})$	1.000	0.817	0.629	0.442
	(s.e.)	(0.000)	(0.034)	(0.062)	(0.086)
Data	$corr(w_t, w_{t-k})$	1.000	0.760	0.783	0.554
Model	$corr(w_t, w_{t-k})$	1.000	0.817	0.632	0.451
	(s.e.)	(0.000)	(0.031)	(0.055)	(0.075)

market paradigm used in Vasilev (2009).

## 6 Conclusions

We augment an otherwise standard business cycle model with a richer government sector, and add a stochastic costly credit production as in Benk et al. (2005), and a modified cash in advance (CIA) considerations. In particular, the cash in advance constraint of Cole (2020) is extended to include private investment and government consumption, and allows an endogenous proportion of total expenditure to be done using credit. This specification is

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
Model	$corr(h_t, (y/h)_{t-k})$	-0.033	-0.023	-0.009	0.759	0.073	0.056	0.046
	(s.e.)	(0.751)	(0.666)	(0.553)	(0.476)	(0.542)	(0.652)	(0.738)
Data	$corr(h_t, w_{t-k})$	0.355	0.452	0.447	0.328	-0.040	-0.390	-0.57
Model	$corr(h_t, w_{t-k})$	-0.033	-0.023	-0.009	0.759	0.073	0.056	0.046
	(s.e.)	(0.751)	(0.666)	(0.553)	(0.476)	(0.542)	(0.652)	(0.738)

then calibrated to Bulgarian data after the introduction of the currency board (1999-2018). The costly credit production mechanism adds little in explaining business cycle fluctuations. Credit shocks by themselves are an unlikely candidate to drive the business cycle. In addition, the modified CIA constraint produces a transmission mechanism that generates too much investment volatility, and too little variability in hours and wages in the model.

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