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EERI Research Paper Series No 09/2017

ISSN: 2031-4892

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A Real-Business-Cycle model with reciprocity in labor relations and a government sector: the case of Bulgaria

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November 14, 2017

Abstract

In this paper we introduce reciprocity in labor relations and government sector to investigate how well the real wage rigidity that results out of that arrangement explains business cycle fluctuations in Bulgaria. The reciprocity mechanism described in this paper follows Danthine and Kurmann (2010) and is generally consistent with micro-studies, e.g. Lozev, Vladova, and Paskaleva (2011) and Paskaleva (2016). Rent-sharing considerations, and worker's own past wages turn out to be the most important aspects of how labor contracting happens. In contrast, aggregate economic conditions, as captured by the employment rate, are not found to be quantitatively important for wage dynamics. Overall, the model with reciprocity and fiscal policy performs well vis-a-vis data, especially along the labor market dimension.

Keywords: general equilibrium, reciprocity, gift exchange, efficiency wages, unemployment, fiscal policy, Bulgaria

JEL Classification Codes: E24, E32, J41

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1 Introduction and Motivation

In this paper we investigate the quantitative importance of reciprocity in labor relations and the downward-rigid efficiency wages that result out of that arrangement in explaining business cycle fluctuations in Bulgaria after the introduction of the currency board arrangement in 1997. Earlier macroeconomic literature, using Dynamic Stochastic General Equilibrium (DSGE) models with perfectly-competitive labor markets, e.g. Vasilev (2009), was not able to capture well the dynamics exhibited by labor market variables (wages, employment and unemployment) in Bulgaria. That is why we need to adapt the standard model, and augment it with a plausible mechanism that deviates from spot wage contracting, and instead move to setups that emphasize the long-term aspects of the labor arrangement. After all, the employer-employee relationship is a multi-period contract problem. Therefore, alternative mechanism of wage contracting are considered here, as those mechanisms, mostly based on non-Walrasian settings, are promising area of research, as pointed in Blanchard and Fischer (1989, p. 463). More specifically, in a recent study, Danthine and Donaldson (1995) distinguish between four types of efficiency wages (qtd in Collard and de la Croix 2000): "(a) those that discourage shirking by raising the opportunity cost of being fired (shirking model), (b) those that reduce quits (turnover cost model), (c) those that improve the applicant pool (screening model), and (d) those that improve efforts by improving morale with a fair wage (gift exchange model)." In this paper we focus on the last type.[1] Similarly, including a government sector, in addition to making the model more realistic, helps the standard Real-Business-Cycle model match data better.

As shown in Paskaleva (2016), real wages in Bulgaria are indeed downward rigid. That is mostly due to collective agreements in place, which prohibit cuts in base wages. Such restrictions mean that adjusting labor costs needs to happen mostly through employment reductions. Lozev, Vladova and Paskaleva (2011) also documents downward real wage rigidity in Bulgaria, even though it is lower than in the other EU member states. For example, more competitive firms use alternative margins of adjustment, eg. bonuses, fringe benefits,

[1] Vasilev (2017) examines the business-cycle properties of a model with efficiency wages of no-shirking type. To the best of our knowledge, we are not aware of general-equilibrium models incorporating efficiency wages of type (b) and (c).

slowing promotions, etc. wages generally adjust once a year.[2]

We use these empirical findings to motivate our modelling approach here. In contrast to Vasilev (2017), where the efficiency wages are of the no-shirking type a la Shapiro and Stiglitz (1984), here the wage contracts are in the spirit of "gift exchange" as in Akerlof (1982). As in Vasilev (2017), effort will be modelled as a productive input in the firm's production function, but it will be unobservable from the employer's perspective, and thus a contract fully specifying the required level of effort can be neither specified nor enforced. The novelty in this paper, however, is that at the core of the labor relations we introduce a consideration that workers may derive "pleasure" from returning a higher than demanded effort level in exchange for a perceived above-market wage rate paid to them by the firm. Firms, being aware of this counter-gift motive on the side of the worker, then set wages in such a way to elicit the maximum amount of effort from a worker and achieve a maximum profit.[3]

In other words, the employer-employee labor relations will feature a certain reciprocity that would generate downward real wage rigidity. Building on Danthine and Kurmann (2007, 2010), the utility benefit from reciprocity is viewed as a product of the worker's and the firm's gift, which are exchanged in the spirit of cooperation and fairness (Rabin 1983). Each side in the relationship compares the benefit from the employment relation relative to some norm. From the worker's perspective, this norm is reflected in several aspects: (i) the worker's outside option, represented by the average going wage and the external labor conditions - availability of jobs, as proxied by the overall employment rate; (ii) rent-seeking considerations - i.e., how output is shared between salaries and profit;[4] (iii) past wages, or

[2]As we see, theories that feature imperfectly competitive labor markets, e.g. the theory of job search and matching, are not in conflict with the theory in this paper, but rather supplement it. More specifically, dividing the rents from the match is determined by the terms in the labor contract, which acts also as risk-sharing mechanism - employer and employee need to agree on how to share the benefits from productive activity in both good and bad times.

[3]As noted in Danthine and Kurmann (2010), this generates a *conditional* downward wage rigidity, as compared to the standard, or *unconditional*, wage rigidity.

[4]Therefore, models with search and matching frictions as in Vasilev (2016) do not exclude possibility of efficiency wages.

the so called "wage entitlement" argument (Danthine and Kurmann 2010). In other words, due to an already existing collective agreement written in the Labor Code the worker expects the wage to increase over time, and not decrease, but only freeze in extreme cases.[5] Allowing effort to depend on past wages helps to introduce sluggishness in wage adjustments and that is what the standard gift exchange model (Akerlof 1982) lacks. Such a past dependence on wages helps the model match better the dynamic cross-correlation between wages and hours worked. This extension also helps increase employment variability.

The rest of the paper is organized as follows. Section 2 briefly reviews the relevant literature. Section 3 lays down the model. Section 4 described the data used and the calibration procedure. Section 5 presents the long-run theoretical properties of the model. Section 6 simulates the model and evaluates its business cycle properties vis-a-vis data in the spirit of Canova (2007), especially the response of main variables to unanticipated technology shock. Section 7 concludes.

2 A Brief Literature Review

A large number of survey studies, e.g., Kahneman, Knetsch and Thaler (1986), Bewley (2002) and experiments e.g. Fehr and Gaechter (1999), all document the existence of reciprocity in labor relations.[6] Akerlof (1982), and Akerlof and Yellen (1990) are two pioneer studies to model reciprocity in labor relations in macroeconomics. However, his model considers the workers reference point to be the outside option, or the expected wage at an alternative employment. Such efficiency/fair wages paid by the employer are good for morale and increase productivity. Importantly, however, rent-sharing and wage entitlement (history of past wages) considerations are not present in Akerlof's (1982) framework. These aspects of "fairness", however, turn out to be quite important in micro evidence, e.g. Bewley (2002).[7]

[5]All these three aspects are seen in Bulgaria, e.g. Lozev, Vladova and Paskaleva (2011) and Paskaleva (2016).

[6]Those papers also report that firms avoid explicit rewards for effort exerted, as those schemes turn out to be either too costly to be implemented, or negatively affecting work morale of workers who do not get the award.

[7]Levine (1993), and Campbell and Kamlani (1997) also emphasize the importance of past wages as a reference point in their studies.

Workers often express a common view that they are entitled to some reference salary, or a "wage norm," while firms are entitled to some reference level of profit, or a "profit norm."[8]

In the modern dynamic macroeconomic literature, Collard and de la Croix (2000) and Danthine and Kurmann (2004) show that including past wage considerations in the reference wage function helps a general-equilibrium macroeconomic model generate substantial downward wage rigidity and improves the overall statistical fit. Relatively recently, Danthine and Kurmann (2010) build on their earlier theoretical work in Danthine and Kurmann (2007) by incorporating rent-sharing arrangements in an otherwise standard monetary model, which then they structurally estimate. In contrast to Danthine and Kurmann (2010), here we stay within the RBC paradigm and instead of estimating the model, we calibrate it to Bulgarian data for the period 1999-2014, which corresponds to the period of stability after the introduction of the currency board arrangement. In addition, for better realism, we introduce a detailed government sector, and analyze the business cycle properties of the model relative to the data in much more detail as compared to earlier studies.

3 Model Setup

The model economy in this paper is populated by households, a representative firm, and a government sector. Aside from the gift exchange mechanism in the labor market, the economy is standard: households maximize utility subject to their budget constraint, the firm maximizes profit, and the government runs a balanced budget constraint by spending on government consumption and transfers exactly what it raises in revenue from taxing labor and capital income. Effort exerted by workers is a productive input in the final goods sector, but unobservable, and thus not directly contractible. However, producers understand that while workers do not like exerting effort, they derive utility from returning the gift of a generous wage by supplying a higher effort level even in an environment of costly monitoring. This leads to the firm paying an efficiency wage.

[8]See Fehr, Gaechter and Kirchsteiger (1997) and Kahnemann, Knetsch and Thaler (1986), among others, for a more detailed treatment on the subject.

3.1 Households

There is a continuum of identical one-member households distributed on the $[0,1]$ interval and indexed by i. Each household i derives utility out of consumption and leisure. As in Danthine and Kurmann (2010), household i's expected discounted total utility is given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t^i + \ln(1-h_t^i) - h_t^i \left[\frac{(e_t^i)^2}{2} - \mathfrak{R}(e_t^i, .) \right] \right\}, \tag{1}$$

where E_0 is the expectation operator conditional on the information available to household i at time 0, $0 < \beta < 1$ denotes the discount factor, c_t^i is consumption of household i in period t, h_t^i is the fraction of time available to household i that is spent working, and e_t^i is the level of effort exerted. The total time endowment available to each household i is normalized to unity, thus leisure, $l_t = 1 - h_t$ is implicitly expressed as time off work.

The novelty in this relatively standard utility function is the last term. In particular, as in Danthine and Kurmann (2010), $\mathfrak{R}(e_t^i, .)$ utility term is included to capture that workers may derive utility out of "reciprocal behavior towards their employer." As long as $\mathfrak{R}_e(e_t^i, .) > 0$, household i would be willing to reward a wage that is perceived to be above the competitive one (even in the absence of any direct material gain resulting from such an action) with a level of effort above the required minimum (say, zero).[9] This way of modelling such a bilateral "gift exchange" between a worker and employer is consistent with earlier works, e.g. Akerlof (1982) and Rabin (1993).

As in Hansen (1985) and Rogerson (1988) household i's labor supply is assumed to be indivisible, i.e. $h_t^i \in \{0, \bar{h}\}, \forall t$. In equilibrium, only a fraction n_t would be selected to work a full shift in each period t. In order to Pareto-improve the consumption bundle received by both workers and non-workers, a lottery market can be included to provide insurance against unemployment (i.e., not being selected for work) in certain period. Such an arrangement would achieve full insurance (efficient risk sharing), so everyone would receive the same consumption independent of the employment status. If we assume that all households pool their

[9] As pointed out in Danthine and Kurmann (2010), this function potentially can feature the wage rate as an argument, among other factors. However, given the atomistic nature of each household, all those variables will be taken as given.

resources together and maximize aggregate welfare, the resulting discounted utility function becomes

$$E_0 \sum_{t=0}^{\infty} \beta^t \Big\{ \ln c_t + n_t^i \Big[\ln(1-\bar{h}) - \frac{(e_t^i)^2}{2} + \mathfrak{R}(e_t^i, .) \Big] \Big\}. \tag{2}$$

Each household starts with $k_0^i = k_0$ initial capital, which is equal to the aggregate capital in period 0. Aggregate capital stock then evolves as follows:

$$k_{t+1} = i_t + (1-\delta)k_t \tag{3}$$

where $0 < \delta < 1$ denotes the depreciation rate on capital. The before-tax rental rate on capital is r_t, and in addition the households have legal claim on all the firm's profit π_t.

In addition to capital income, households receive labor income as well. The hourly wage rate in the economy is w_t, so the total before-tax labor income generated in each period is $w_t n_t \bar{h}$. The aggregate household's budget constraint is then

$$c_t + k_{t+1} - (1-\delta)k_t = (1-\tau)w_t n_t \bar{h} + (1-\tau)r_t k_t + \pi_t + g_t^t, \tag{4}$$

where τ is the common income tax rate, and g_t^t are aggregate government transfers. The problem now is to maximize aggregate utility (2) subject to the aggregate budget constraint (4). The first-order optimality conditions are as follows:

$$c_t \quad : \quad \frac{1}{c_t} = \Lambda_t \tag{5}$$

$$e_t \quad : \quad e_t = \mathfrak{R}_e(e_t, .) \tag{6}$$

$$n_t \quad : \quad \ln(1-\bar{h}) - \frac{(e_t^i)^2}{2} + \mathfrak{R}(e_t^i, .) = \Lambda_t w_t \bar{h} \tag{7}$$

$$k_{t+1} \quad : \quad \Lambda_t = E_t \Lambda_{t+1}[1 + (1-\tau)r_{t+1} - \delta] \tag{8}$$

$$TVC \quad : \quad \lim_{t\to\infty} \Lambda_t k_{t+1} = 0, \tag{9}$$

where Λ_t is the Lagrangian multiplier attached to the household's budget constraint. The first optimality condition equates the marginal utility of consumption to the marginal utility of wealth. The second condition is called the Effort Condition (EC), or Solow (1979) condition. The third condition is the employment optimality condition. The fourth is the so called Euler equation, which describes the optimal allocation of capital in any two adjacent periods. The last condition, the Transversality condition (TVC), is a boundary condition that needs to be imposed to eliminate explosive solutions.

3.2 Reciprocity

As in Danthine and Kurmann (2010), we follow the approach of Rabin (1993), and more specifically, its adaptation to macroeconomic (though not general-equilibrium) setting by Danthine and Kurmann (2007) and represent the reciprocity $\mathfrak{R}(e_t, .)$ term in the household's utility function as a product of the mutual "gifts" of an employed household and the representative firm:

$$\mathfrak{R}(e_t, .) = d(e_t)g(w_t), \tag{10}$$

where $d(e_t)$ denote the gift of the employed household towards the firm, expressed in terms of effort exerted, and $g(W_t, .)$ is the counter-gift of the firm to the worker in terms of the wage rate paid. Both terms are assumed to be concave in their respective arguments, i.e. $d_e(e_t) > 0, d_{ee}(e_t) < 0$ and $g_w(w_t) > 0, g_{ww}(w_t) < 0$. Hence, when a worker receives a wage offer that is perceived as generous (e.g. a wage above the competitive rate), i.e. $g(w_t) > 0$, the household's utility increases if there is a reciprocal gift expressed in terms of higher effort, $d(e_t) > 0$. In addition, from the perspective of an atomistic worker, the wage rate is taken as given, that is why $d_w(e_t) = 0$. In addition, employed households do not take into consideration the effect of their (individual) effort on the firm's output, and hence on the gift made by the firm to the worker, i.e., $g_e(w_t) = 0$ from the perspective of an employed household.

Note that in defining the two gifts, both are expressed as deviations from some expected norm ("reference level"). To simplify the analysis, we will normalize the minimum acceptable effort level to be $e_{min} = 0$. The worker's gift then can be expressed as:

$$d(e_t) = e_t^{\alpha}, \tag{11}$$

with $0 < \alpha < 1$.[10]

[10]This parameter is set intentionally the same as the labor share in the firm's production function. As shown in Danthine and Kurmann (2010), the dynamics of the model does not change when a multiplicative scale factor is added to the worker's gift, e.g. $d(e_t, .) = Be_t^{\alpha}$ or when the minimum effort is set to $e_{min} = \underline{e}$, so $d(e_t, .) = (e_t - \underline{e})^{\alpha}$.

Next, modelling the firm's gift follows an agnostic approach. In other words, we will follow Collard and de la Croux (2000) and Danthine and Kurmann (2010) and utilize an encompassing specification that would allow us to discriminate between different theories when subjected to empirical tests.[11] We define the firm's gift as follows:

$$\begin{aligned} g(w_t) &= \ln(1-\tau)w_t - \varphi_1 \ln(1-\tau)\frac{Y_t}{n_t} \\ &\quad -\varphi_2 \ln(1-\tau)\bar{w}_t\bar{n}_t - \varphi_3 \ln\Bigg[(1-\tau)[s\bar{w}_{t-1} + (1-s)w_{t-1}]\Bigg], \end{aligned} \tag{12}$$

where the first term on the right-hand-side, $\ln(1-\tau)w_t$, is the utility benefit resulting from a higher consumption, which the worker attributes to the firm's wage offered. The remaining terms in $g(w_t)$ are a weighted average of utility levels under different compensations (which are connected to different reference points).[12] More specifically, $\ln(1-\tau)\frac{Y_t}{n_t}$ term has to do with rent-sharing considerations between the firm and the worker, as it represents the surplus to be shared (worker's product). In this case it represents a case where the firm distributes all the revenue to its workers. The term $\ln(1-\tau)\bar{w}_t\bar{n}_t$ represents an outside option, the alternative income that the worker can earn if s/he leaves the firm. Lastly, the term $\ln\Bigg[(1-\tau)[s\bar{w}_{t-1} + (1-s)w_{t-1}]\Bigg]$ is the utility obtained from a convex combination of salaries under different reference norms, where the first case uses the past average wage in the economy (i.e. the "social norm"), while the second case takes the worker's own past wage as the reference point (i.e. "personal norm"). With $s = 1$, the last utility term is the pure "social norm case," while when $s = 0$ we consider a pure "personal norm" scenario.[13]

We can rewrite the firm's gift as follows

$$\begin{aligned} g(w_t) &= \ln w_t - \varphi_1 \ln\frac{Y_t}{n_t} - \varphi_2 \ln \bar{w}_t\bar{n}_t - \varphi_3 \ln[s\bar{w}_{t-1} + (1-s)w_{t-1}], \\ &\quad +(1-\varphi_1-\varphi_2-\varphi_3)\ln(1-\tau) \end{aligned} \tag{13}$$

[11]Note that the specification of the firm's gift is of critical importance, as it would affect the optimal wage offer made by the firm.

[12]In other words, $\varphi_1 + \varphi_2 + \varphi_3 = 1$.

[13]In what is to follow, the individual and average past wage are going to be the same.

Abstract away from the tax term,[14] to obtain

$$g(w_t) \;=\; \ln w_t - \varphi_1 \ln \frac{Y_t}{n_t} - \varphi_2 \ln \bar{w}_t \bar{n}_t - \varphi_3 \ln[s\bar{w}_{t-1} + (1-s)w_{t-1}]. \tag{14}$$

Plugging this expression into the optimal effort condition

$$e_t = \Re_e(e_t, .) = d_e(e_t)g(w_t), \tag{15}$$

where the last equality follows from the assumption that $g(w_t)$ did not vary with e_t. Given our functional forms that results in $e_t = \alpha e_t^{\alpha-1} g(w_t)$, or $e_t^{2-\alpha} = \alpha g(w_t)$. Rearranging terms, we can express the wage rate as

$$e_t^{2-\alpha} = \alpha \left[\ln w_t - \varphi_1 \ln \frac{Y_t}{n_t} - \varphi_2 \ln \bar{w}_t \bar{n}_t - \varphi_3 \ln[s\bar{w}_{t-1} + (1-s)w_{t-1}] \right].$$

or

$$\ln w_t = \frac{e_t^{2-\alpha}}{\alpha} + \varphi_1 \ln \frac{y_t}{n_t} + \varphi_2 \ln \bar{w}_t \bar{n}_t + \varphi_3 \ln[s\bar{w}_{t-1} + (1-s)w_{t-1}]$$

From this equation it follows that the wage rate set by the firm positively depends on the firm's revenue per worker ($\varphi_1 > 0$), as it increases the total surplus/rent of the labor relationship. This is also referred to as a rent-sharing motive. When $\varphi_2 > 0$, the wage is increasing in the average wage in the economy and the level of employment, which are proxies of the external labor conditions. If $\varphi_3 > 0$, the firm's optimal wage rate would also depend on the past wage, or the so-called "wage entitlement effect" as referred to in Danthine and Kurmann (2010).

Using that $1 = \varphi_1 + \varphi_2 + \varphi_3$, and that the individual wage and employment are the same as the average wage and employment, i.e. $w_t = \bar{w}_t$, and $n_t = \bar{n}_t$ one can obtain[15]

$$\ln w_t = \frac{e_t^{2-\alpha}}{\alpha} + \varphi_1 \ln \frac{y_t}{n_t} + \varphi_2 \ln w_t + \varphi_2 n_t + \varphi_3 \ln[sw_{t-1} + (1-s)w_{t-1}]$$

Substituting for output and log-linearizing around the steady state produces

$$\hat{w}_t = \frac{\varphi_1}{\varphi_1 + \varphi_3}\hat{a}_t + \frac{\varphi_1(1-\alpha)}{\varphi_1 + \varphi_3}\hat{k}_t + \frac{1 - (2-\alpha)\varphi_1 - \varphi_3}{\varphi_1 + \varphi_3}\hat{n}_t + \frac{\varphi_3}{\varphi_1 + \varphi_3}\hat{w}_{t-1} \tag{16}$$

[14] Danthine and Kurmann (2010) prove that stationarity of effort and the share of labor require $\varphi_1 + \varphi_2 + \varphi_3 = 1$.

[15] For $s = 1$, the equilibrium effort level is $e = \left[\frac{\alpha(1-\varphi_1)}{2-\alpha}\right]^{\frac{1}{2-\alpha}}$.

The wage-setting equation above is crucial for the business cycle dynamics of the wage rate in the model. It states that the deviation of wages is a function of deviations in not only technology, capital and employment, but also lagged wages. However, we will postpone the discussion on the quantitative importance of this equation until the simulation stage.

3.3 Firm

There is a stand-in firm produces a homogeneous final good that can be used for consumption, investment, or government purchases. The Cobb-Douglas production function uses physical capital and efficiency labor as inputs an is as follows:

$$y_t = A_t k_t^{1-\alpha}(e_t n_t \bar{h})^{\alpha}, \tag{17}$$

where A_t captures the level of technology at time t, $0 < \alpha < 1$ is the capital share, and $1-\alpha$ is the efficiency labor share.

The firm maximizes profit subject to the household's participation condition and effort condition being satisfied, which turns the firm's problem becomes dynamic. More specifically, this is because the wage set today influences effort next period through the existence of past wage, w_{t-1} as an argument in the effort condition.[16] The firm discounts profit by the stochastic discount factor (expressed in utility terms) $\Lambda_t = \frac{1}{c_t}$, hence the firm's dynamic problem is as follows:

$$\max_{k_t, w_t, n_t} \sum_{t=0}^{\infty} \beta^t \Lambda_t [A_t k_t^{1-\alpha}(e_t n_t \bar{h})^{\alpha} - w_t n_t \bar{h} - r_t k_t] \tag{18}$$

The resulting first-order conditions are

$$k_t \; : \; (1-\alpha)\frac{y_t}{k_t} = r_t. \tag{19}$$

$$n_t \; : \; \alpha\frac{y_t}{n_t} + \alpha\frac{y_t}{e_t}\frac{n_t}{n_t}\frac{\partial e_t}{\partial n_t} = w_t \bar{h} \tag{20}$$

$$w_t \; : \; \alpha\frac{\partial y_t}{\partial e_t}\frac{\partial e_t}{\partial w_t} + E_t\left[\beta\frac{\Lambda_{t+1}}{\Lambda_t}\frac{\partial y_t}{\partial e_t}\frac{\partial e_t}{\partial w_t}\right] = n_t \bar{h} \tag{21}$$

The first condition describes optimal renting of capital: in equilibrium it receives its marginal product. The second condition characterizes labor demand by the firm: in this setup there

[16] In other words, wages become a state variable.

is an elasticity term, $\frac{\partial e_t}{\partial n_t}\frac{n_t}{e_t} \geq 0$, which appears to capture the effect of a new margin of adjustment. More specifically, a higher level of employment, though costly in terms of labor productivity, may actually increase the value of the firm's gift (wage paid) and in turn worker's counter-gift (worker's effort).[17] In other words, given the dynamic implications of the wage on the effort exerted, the firm is hiring more people as compared to the perfectly competitive, perfect effort observability case.

The last equation describes how efficiency wages are set, i.e. how the firm chooses a wage rate to inspire the worker to supply optimum effort. Combining the optimality conditions for employment and wages produces:

$$1 = \epsilon(e_t, w_t) - \epsilon(e_t, n_t) + \beta E_t\left[\frac{\Lambda_{t+1}}{\Lambda_t}\frac{y_{t+1}}{y_t}\epsilon(e_{t+1}, w_t)\right], \tag{22}$$

where $\epsilon(e_t, w_t) = \frac{\partial e_t}{\partial w_t}\frac{w_t}{e_t}$ denotes the elasticity of effort level with respect to the wage rate and $\epsilon(e_{t+1}, w_t) = \frac{\partial e_t}{\partial w_t}\frac{w_t}{e_{t+1}}$ denotes the elasticity of next-period effort level with respect to the current wage rate. Danthine and Kurmann (2010) refer to this equation as the *Modified Solow Condition* (MSC).[18] In this case, as Danthine and Kurmann (2010) show, with $\epsilon(e_t, w_t) > 0$, the standard Solow (1979) condition does not apply, since an increase in the wage rate at the margin produces an extra increase in worker's productivity (which in turn would decrease the firm's gift and worker's effort/counter-gift). Similarly, with $\epsilon(e_{t+1}, w_t) < 0$ under our specification here, the firm has to take into consideration the future effect of the current wage rate - a higher wage paid today makes it more costly to extract higher effort from a worker in the future.

3.4 Government

The government will be assumed to be running a balanced budget in every period. The government collects revenue from levying taxes on capital and labor income, and then spends

[17] Using an analogy from finance, from the firm's point of view, the worker is a multi-period asset.

[18] Note that when $\epsilon(e_t, n_t) = 0$ (i.e., in the absence of reciprocity in labor relations) and $\epsilon(e_{t+1}, w_t) = 0$ (i.e. the past wage rate does not matter), the MSC reduces to Solow's (1979) original condition, which states that at the optimum wage, the costs per efficiency unit of labor are minimizes, or the average cost per efficiency unit of labor equals the average cost per unit of labor.

on government consumption and transfers, which are returned lump-sum to the households:

$$\tau[r_t k_t + w_t n_t h] = g_t^c + g_t^t, \tag{23}$$

where g_t^c are government purchases. Government spending share will be set equal to its long-run average, so the level will be varying with output. Government transfers will be residually determined and will always adjust to make sure the budget is balanced.

3.5 Decentralized Dynamic Equilibrium with Efficiency Wages

Given the process followed by total factor productivity $\{A\}_{t=0}^{\infty}$, average effective income tax rate $\{\tau\}$, initial capital endowments stock k_0, hours worked per household h, the decentralized dynamic equilibrium with efficiency wages is a list of sequences $\{c_t, i_t, k_t, n_t, e_t\}_{t=0}^{\infty}$ for each household i, input levels $\{k_t, n_t, e_t\}$ 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 by setting an efficiency wage to satisfy the workers' incentive compatibility constraint and to induce an optimal effort level; (iii) government budget is balanced in each period; (iv) all markets clear.

4 Data and model calibration

When modelling business cycle fluctuations in Bulgaria, we will focus on the period after the introduction of the currency board (1999-2014). Data on output, consumption and investment was collected from National Statistical Institute (2015), while the real interest rate is taken from Bulgarian National Bank Statistical Database (2015). The calibration strategy described in this section follows Kydland and Prescott (1982) and Vasilev (2015c). First, as in Vasilev (2016c), the average income tax rate was set to its (average effective) rate $\tau = 0.100$. The depreciation rate of physical capital in Bulgaria, $\delta = 0.05$, is taken from Vasilev (2015a). The discount factor, $\beta = 0.942$, is set to match the steady-state capital-to-output ratio in Bulgaria, $k/y = 3.491$, in the steady-state Euler equation. The labor share parameter, $\alpha = 0.429$, was obtained as the average value of labor income in aggregate output over the period 1999-2014.[19] Next, steady state employment rate in Bulgaria is set to $n = 0.533$, as in Vasilev (2016a). Following Vasilev (2015b), $h = 1/3$. The values for $\varphi_1, \varphi_2, \varphi_3$ were estimated from (16). Finally, as in Vasilev (2016b), the moments of the total factor productivity process were obtained from running an AR(1) regression on the detrended Solow residuals. Table 1 below summarizes the values of all model parameters used in the paper.

[Table 1 about here.]

5 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. The steady-state level of output was normalized to unity (hence the level of technology A differs from unity), which greatly simplified the computations, and allows the steady-state to be solved by hand. Next, 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 follows directly from the constant-returns to scale featured by the aggregate production function. The after-tax return, where $\tilde{r} = (1 - \tau^y)r - \delta$ is also relatively well-captured by the model.

[Table 2 about here.]

6 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

[19] This value is slightly higher as compared to other studies on developed economies, due to the overaccumulation of physical capital during Communism.

factor productivity process, and then we fully simulate the model to compare how the second moments of the model perform when compared against their empirical counterparts. As in Vasilev (2016a, 2017), special focus is put on the cyclical behavior of labor market variables.

6.1 Impulse Response Analysis

This subsection documents the impulse responses of model variables to a 1% surprise innovation to technology. The impulse response function (IRFs) are presented in figure 1 on the next page. As a result of the one-time unexpected positive shock to total factor productivity, output increases. This expands the availability of resources in the economy, so consumption, investment and government consumption also increase upon impact. After the impact, all those variables returns to their steady-states within ten periods. Hours react a lot on impact, then display a hump-shaped behavior until they return to their original steady-state value. The real wage also hardly reacts on impact and then returns to its steady state. Note that similar to the the shirking model in Vasilev (2017), after a surprise innovation in technology, there is a large response to employment with a relatively smaller increase in the real wage. In other words, the wage rate here also exhibits real rigidity.

In terms of the specific mechanics of gift exchange mechanism at work in this model, the stronger the rent-sharing considerations (larger φ_1), the stronger is the direct effect of the shocks to technology on wages, and in turn the smaller is then the wage response to volatility in employment/total hours worked. More specifically, given the large response in hours in the face of the technological shock, rent-sharing channel reduce the wage response. In other words, since in our parametrization for Bulgaria $1-(2-\alpha)\varphi_1-\varphi_3<0$ (i.e., φ_1 "sufficiently large"), wages and employment move in opposite directions.

The quantitative effect of the entitlement considerations in the model is captured by the value of φ_3. In other words, the larger the persistence of wages, and the smaller would be the effects of movement in technology and employment. Again, since in our parametrization for Bulgaria $1-(2-\alpha)\varphi_1-\varphi_3<0$ (i.e., φ_3 "sufficiently large"), again wages and employment move in opposite directions.[20]

[Figure 1 about here.]

Over time, as capital is being accumulated, its marginal product starts to decrease, which lowers the households' incentives to save. As a result, capital eventually returns to its steady-state, and exhibits a hump-shaped dynamics over the transition path. Consumption also exhibits the same shape in its dynamic pattern. With efficiency wages, the variation in the wage rate follows exactly the variations in consumption. The rest of the variables return to their old steady-states very quickly as the effect of the one-time surprise innovation in technology dies out.

6.2 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 below summarizes the second moments of data (relative volatilities to output, and contemporaneous correlations with output) versus the same moments computed from the model-simulated data at quarterly frequency.[21] To minimize the sample error, the simulated moments are averaged out over the computer-generated draws. The model matches quite well the absolute volatility of output. However, the model overestimates the variability in consumption, and investment. Still, the model is qualitatively consistent with the stylized fact that consumption generally varies less than output, while investment is more volatile than output. By construction, government spending in the model varies as much as in data.

[Table 3 about here.]

With respect to the labor market variables, the variability of employment predicted by the model is much more than in data, while the variability of unemployment is much closer to the volatility exhibited in data. The variability of wages is well-matched: As in the efficiency wage model of no-shirking variety, e.g. as in Vasilev (2017), in the presence of reciprocity in

[20] The common effect of rent-sharing and wage entitlement aspects in the gift exchange mechanism is connected to their effect on the marginal costs of hiring efficiency labor that works in the same direction.

[21] The model-predicted 95 % confidence intervals are available upon request.

labor relations wages vary as much as consumption.[22]

Next, in terms of contemporaneous correlations, the model slightly over-predicts the procyclicality of the main aggregate variables - consumption, investment, and government consumption. This, however, is a common limitation of this class of models. However, along the labor market dimension, the contemporaneous correlation of employment with output, and unemployment with output, is relatively well-matched. With wages, the model predicts strong pro-cyclicality, while wages in data are acyclical. This is an artifact of the fair wage which establishes a bi-directional link with labor productivity as a result of the "gift exchange" mechanism. In addition, wages in such setups are as variable as consumption. Overall, the model with efficiency wages shows promise to explain better labor markets dynamics in Bulgaria than a search-and-matching model (Vasilev 2016a).[23]

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.

6.3 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. As seen from table 4 on the next page, the model compares well vis-a-vis data. Empirical ACFs for output and investment are slightly outside the confidence band predicted by the model, while the ACFs for total factor productivity and household consumption are well-approximated by the model.

[22]Thus, wages of efficiency type could be serving as a good approximation for the behavior of workers whose income is mostly labor earnings.

[23]A model with both search and matching frictions and efficiency wages could thus potentially explain the best of both worlds. Such setup, however, is left for future research.

[Table 4 about here.]

Overall, the model with reciprocity in labor relations generates too high persistence in output and both employment and unemployment, but 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. Furthermore, the reciprocity in labor relations mechanism dominates the setup with invisible hours, developed by Rogerson (1988), and incorporated in the RBC setup by Hansen (1985).[24]

Next, as seen from table 5 on the next page, over the business cycle, in data labor productivity leads employment. The model with fair wages, however, cannot account for this fact.[25] Therefore, the effect between employment and labor productivity is only a contemporaneous one. Still, the model with reciprocity in labor relations is a clear improvement over the perfectly-competitive labor market paradigm used in Vasilev (2009, 2016b), but performs slightly worse than the efficiency wages of no-shirking type as in Vasilev (2017), and much worse than the search and matching mechanism in Vasilev (2016a).

[Table 5 about here.]

[24] In those models, labor market is modelled in the Walrasian market-clearing spirit, and output and unemployment persistence is low.

[25] 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.

7 Conclusions

In this paper we investigate the quantitative importance of efficiency wages in explaining fluctuations in Bulgarian labor markets. In contrast to Vasilev (2017) who introduces wages of no-shirking type a la Shapiro and Stiglitz (1984), here we incorporated reciprocity arrangement in labor relations and wage determination a la "gift exchange" as in Akerloff (1982) in particular, into a relatively standard RBC model with government sector. We calibrated the model to Bulgarian data after the introduction of the currency board arrangement, and studied the impulse responses of aggregate variables in the face of exogenous technological and fiscal shocks.Overall the calibrated model with gift exchange mechanism performs well vis-a-vis data when it comes to relative volatilities of time series, auto- and cross-correlation functions, and in addition dominates both the market-clearing labor market framework featured in the standard RBC model, *e.g* Vasilev (2009).

The results suggest that workers' own past wage level, but also rent-sharing aspects - tied to the firm's generated surplus, or alternatively, its ability to pay, are the most important determinants of wages in Bulgaria over the period 1999-2015. On the other hand, aggregate labor market condition, as proxied by the employment rate in the economy, turn out to be of lesser importance. Our findings for Bulgaria are generally in line with survey studies on reciprocity in firm-workers labor relations and wage-setting mechanisms, as documented in Lozev, Vladova and Paskaleva (2011) and Paskaleva (2016).

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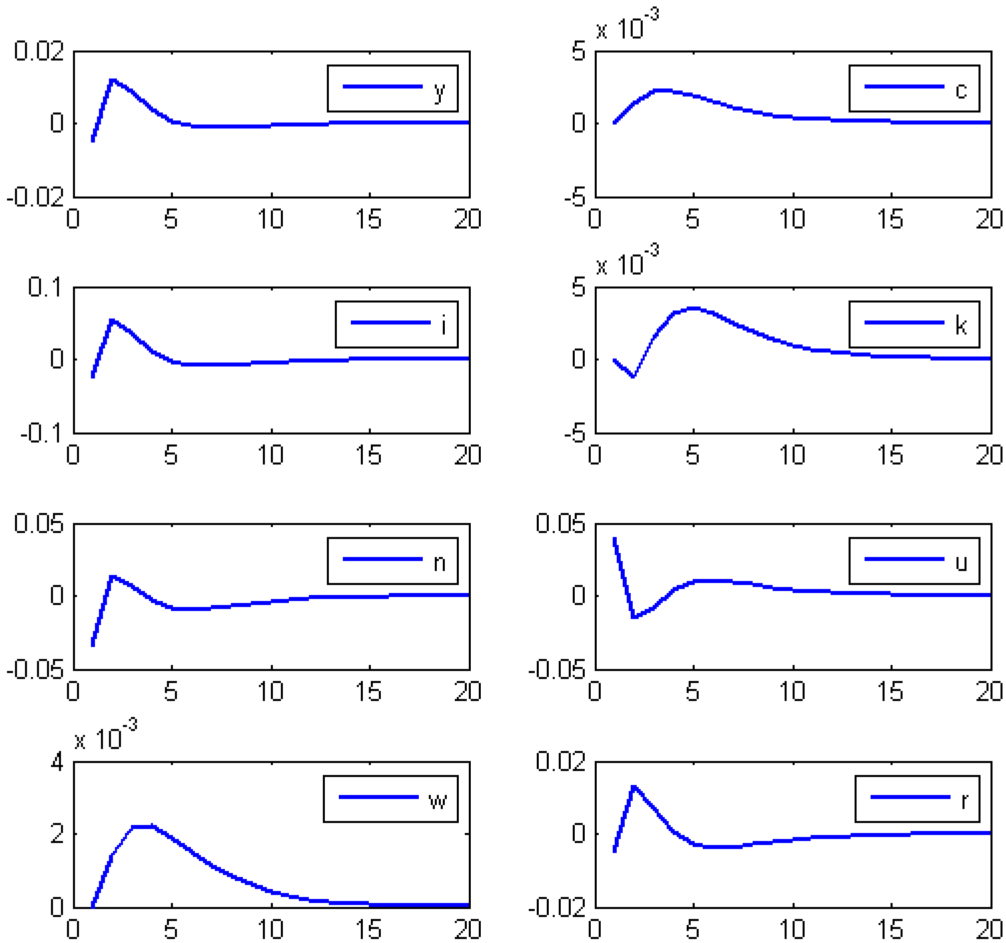

Figure 1: Impulse Responses to a 1% surprise innovation in technology

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Table 1: Model Parameters

Parameter	Value	Description	Method
β	0.942	Discount factor	Calibrated
α	0.429	Labor Share	Data average
$1-\alpha$	0.571	Capital Share	Calibrated
δ	0.050	Depreciation rate on physical capital	Data average
$\bar{h}$	0.333	Share of time spent working	Calibrated
n	0.533	Employment rate	Data average
φ_1	0.168	Weight attached to rent-sharing consideration	Estimated
φ_2	0.096	Weight attached to external labor conditions	Estimated
φ_3	0.736	Weight attached to wage-entitlement consideration	Estimated
τ	0.100	Average tax rate on income	Data average
ρ_a	0.701	AR(1) parameter, total factor productivity	Estimated
σ_a	0.044	st.dev, total factor productivity	Estimated

Table 2: Data Averages and Long-run Solution

Variable	Description	Data	Model
y	Steady-state output	N/A	1.000
c/y	Consumption-to-output ratio	0.674	0.674
i/y	Investment-to-output ratio	0.201	0.175
g^c/y	Government cons-to-output ratio	0.159	0.151
k/y	Capital-to-output ratio	3.491	3.491
wnh/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
n	Employment rate	0.533	0.533
u	Unemployment rate	0.467	0.467
e	Effort level	N/A	0.389
A	Scale parameter of the production function	N/A	1.062
$\tilde{r}$	After-tax net return on capital	0.056	0.061

Table 3: Business Cycle Moments

	Data	Model
σ_y	0.05	0.05
σ_c/σ_y	0.55	0.71
σ_i/σ_y	1.77	2.92
σ_g/σ_y	1.21	1.00
σ_n/σ_y	0.63	3.52
σ_w/σ_y	0.83	0.71
σ_u/σ_y	3.22	4.02
σ_w/σ_n	1.32	0.20
$corr(c, y)$	0.85	0.83
$corr(i, y)$	0.61	0.86
$corr(g, y)$	0.31	1.00
$corr(n, y)$	0.49	0.73
$corr(w, y)$	-0.01	0.83
$corr(u, y)$	-0.47	-0.73
$corr(n, w)$	-0.14	-0.97

Table 4: Autocorrelations for Bulgarian data and the model economy

		k			
Method	Statistic	0	1	2	3
Data	$corr(u_t, u_{t-k})$	1.000	0.765	0.552	0.553
Model	$corr(u_t, u_{t-k})$	1.000	0.958	0.907	0.849
	(s.e.)	(0.000)	(0.026)	(0.050)	(0.073)
Data	$corr(n_t, n_{t-k})$	1.000	0.484	0.009	0.352
Model	$corr(n_t, n_{t-k})$	1.000	0.958	0.907	0.849
	(s.e.)	(0.000)	(0.026)	(0.050)	(0.073)
Data	$corr(y_t, y_{t-k})$	1.000	0.810	0.663	0.479
Model	$corr(y_t, y_{t-k})$	1.000	0.946	0.882	0.808
	(s.e.)	(0.000)	(0.032)	(0.061)	(0.088)
Data	$corr(a_t, a_{t-k})$	1.000	0.702	0.449	0.277
Model	$corr(a_t, a_{t-k})$	1.000	0.955	0.901	0.838
	(s.e.)	(0.000)	(0.027)	(0.052)	(0.077)
Data	$corr(c_t, c_{t-k})$	1.000	0.971	0.952	0.913
Model	$corr(c_t, c_{t-k})$	1.000	0.957	0.905	0.844
	(s.e.)	(0.000)	(0.027)	(0.052)	(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	0.935	0.859	0.772
	(s.e.)	(0.000)	(0.037)	(0.069)	(0.098)
Data	$corr(w_t, w_{t-k})$	1.000	0.760	0.783	0.554
Model	$corr(w_t, w_{t-k})$	1.000	0.957	0.905	0.844
	(s.e.)	(0.000)	(0.027)	(0.052)	(0.076)

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

		k						
Method	Statistic	-3	-2	-1	0	1	2	3
Data	$corr(n_t, (y/n)_{t-k})$	-0.342	-0.363	-0.187	-0.144	0.475	0.470	0.346
Model	$corr(n_t, (y/n)_{t-k})$	0.080	0.080	0.080	0.212	-0.037	-0.050	-0.055
	(s.e.)	(0.340)	(0.298)	(0.247)	(0.296)	(0.197)	(0.236)	(0.236)
Data	$corr(n_t, w_{t-k})$	0.355	0.452	0.447	0.328	-0.040	-0.390	-0.57
Model	$corr(n_t, w_{t-k})$	-0.029	-0.040	-0.055	-0.967	-0.326	-0.239	-0.171
	(s.e.)	(0.327)	(0.283)	(0.231)	(0.073)	(0.242)	(0.281)	(0.318)