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Are Labor Unions Important for Business Cycle Fluctuations: Lessons from Bulgaria (1999-2016)

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Are labor unions important for business cycle fluctuations: lessons from Bulgaria (1999-2016)

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Abstract

In this paper we investigate the quantitative importance of collective agreements in explaining fluctuations in Bulgarian labor markets. Following Maffezzoli (2001), we introduce a monopoly union in a real-business-cycle model with government sector. We calibrate the model to Bulgarian data for the period following the introduction of the currency board arrangement (1999-2016), and compare and contrast it to a model with indivisible labor and no unions as in Rogerson and Wright (1988). We find that the sequential bargaining between unions and firms produces an important internal propagation mechanism, which fits data much better that the alternative framework with indivisible labor.

Keywords: business cycles, general equilibrium, labor unions, indivisible labor, involuntary unemployment.

JEL Classification: E32, E24, J23, J51

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1 Introduction and Motivation

The standard real business cycle model with a perfectly-competitive labor market, *e.g.* Kydland and Prescott (1982) and Long and Plosser (1983), was shown to be unable to capture the dynamics in the labor markets in the US. For Bulgaria, Vasilev (2009) documented a similar failure for wage and employment fluctuations. Most of those earlier studies have tried to explained the mismatch with the modelling choice assuming perfect information and market-clearing, and the absence of involuntary unemployment. Bulgaria, however, as many other Eastern European countries as well, exhibits a significant rate of involuntary unemployment, which was due to the process of structural transformation. In other words, being out of job is not an optimal choice, but rather represents an inefficient outcome, as it produces a waste of non-storable labor resources.

Modelling unemployment as inefficiency requires a departure from the Walrasian (market-clearing) models of labor markets. In other words, only when certain imperfections in labor market are present in the model, can involuntary unemployment appear. One aspect of labor market frictions is the presence of collective bargaining arrangements between labor unions and firms. Fig. 1 below documents their importance in Bulgaria.

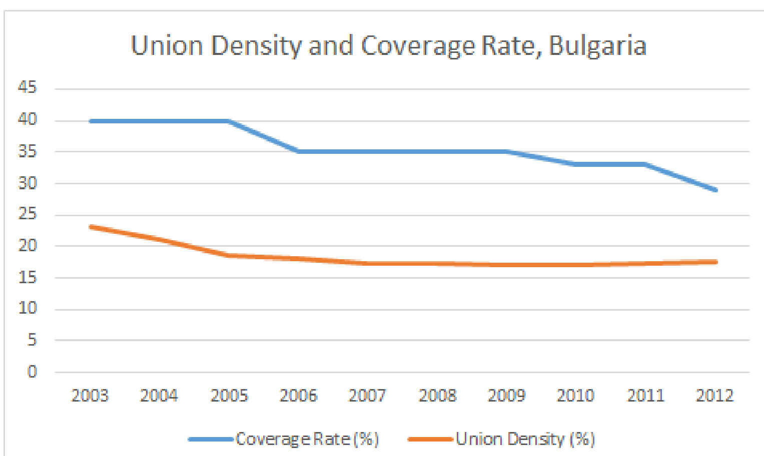

Figure 1: Union Density and Coverage Rates in Bulgaria (1999-2016)
Source: European Trade Union Institute (2018)

Despite a fall in the overall unionization rate, measured by "union density," over the period, and the decentralization of collective bargaining to firm level, collective agreements are still important on the aggregate level - over a third of employed workers in Bulgaria are covered by some form of collective agreement. Moreover, given that such agreements are in the largest firms (and in the public sector), the remaining firms generally follow closely those agreements in the non-unionized sectors as well. For example, as shown in Paskaleva (2016), real wages in Bulgaria are downward rigid, mostly due to collective agreements in place, which prohibit cuts in base wages, and only wage freeze are possible. Such restrictions mean that adjusting labor costs needs to happen mostly through employment reductions. Lozev *et al.* (2011) also documents downward real wage rigidity in Bulgaria, even though it is lower than in the other EU member states. Such real rigidities in the labor market could represent a qualitatively important propagation mechanism that, in addition to making the setup more realistic, can help the model economy replicate data behavior, especially along the labor market dimension.

We use these empirical findings to motivate our modelling approach. In this paper we take unions as important agents for the economic environment, and adapt the standard Dynamic Stochastic General Equilibrium (DSGE) model by augmenting it with a plausible mechanism of collective wage bargaining that deviates from spot wage contracting, and instead emphasize institutional labor arrangement. Furthermore, the alternative mechanism of wage contracting considered here is also based on non-Walrasian settings, and thus are promising area of research, as pointed in Blanchard and Fischer (1989, p. 463).

We follow Maffezolli (2001), and introduce labor unions in the general-equilibrium setup, in oder to study their quantitative implications for business cycle fluctuations in Bulgaria. Zanetti (2007) uses a similar mechanism to Maffezzoli (2001) but in a New-Keynesian framework. His focus is also slightly different from ours. In contrast to Vasilev (2015c), who introduces a union in the government sector, here the union is to be interpreted as a private-sector union, as we do not model public employment explicitly. In addition, most of the big unions cover both private- and public-sector employees. Another novelty relative to the setup in Maffezzoli (2001) is that we make the reservation wage in the union objective conditional on the total factor productivity, which, aside from making the model more realistic, further improves the model fit. In addition, we also discuss the business cycle properties of wages, and the dynamic correlation between employment and the wage rate, which Maffezzoli (2001) does not do.

We proceed to calibrate the model to Bulgarian data after the introduction of the currency board arrangement, which was a period of aggregate stability, and study the impulse responses of aggregate variables in the face of exogenous technological shocks. We compare and contrast the union model against a model with indivisible labor, and more specifically to the Rogerson and Wright (1988) setup with inseparable utility in consumption and leisure. The latter was chosen as it was shown in King and Rebello (2000) to dominates the standard model with divisible hours. Also, the indivisible labor model is more realistic, when compared to the setup with divisible labor, Vasilev (2009), as in Bulgaria most of the people work full-time, so the variablity in hours happens mostly along the extensive margin (employment), and not that much along the intensive (hours per worker).

Overall, the calibrated model with collective bargaining mechanism between the union and the firm provides a tractable general-equilibrium setup, which 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 with indivisible labor as in Rogerson and Wright (1988). More specifically, the presence of the union labor productivity in the model to lead employment over the business cycle, which is what we observe in the data as well. The very low dynamic correlation between wages and employment in Bulgaria is well-approximated in the model, mostly due to the fact that the wage rate comes about through a sequential bargaining procedure. The model with unions also generates persistence in output and both employment and unemployment, and is able to respond to the criticism in Nelson and Plosser (1992), Cogley and Nason (1995), Rotemberg and Woodford (1996), and Hall (1999) who all argue that RBC models generally do not have a strong internal propagation mechanism (besides the strong persistence in the TFP process).

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. Sections 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.

2 Model Description

There is a continuum of homogeneous households which derive utility out of consumption and leisure. The time available to households can be spent in productive use or as leisure. The government taxes consumption spending, and levies a common proportional tax on all income, in order to finance non-productive purchases of government consumption goods, government transfers, and the public sector wage bill. On the production side, there is a representative firm, which hires labor and capital to produce a homogenous final good, which could be used for consumption, investment, or government purchases. The wage rate in the economy is determined by a utility-maximizing union, as in Maffezzoli (2001), subject to the conditional labor demand.

2.1 Households

Each household i, $i \in [0, 1]$, maximizes the following utility function, which, as in Rogerson and Wright (1988), is non-separable in consumption and leisure:

$$\max_{\{c_t^i, h_t^i\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{[c_t^i(1-h_t^i)^{\psi}]^{1-\mu}}{1-\mu}, \tag{1}$$

where E_0 is the expectation operation conditional on information available as of $t = 0$, $0 < \beta < 1$ is the discount factor, c_t^i is individual household consumption in period t, and h_t^i are total hours worked. Parameter $\psi > 0$ reflects the relative weight attached to disutility of work, and $\mu > 1$ captures the curvature of the utility function.

Each household i faces a non-convex labor supply decision, $h_t^i \in \{0; \bar{h}\}, \forall t$, with $\bar{h} < 1$. Hours supplied to the representative firm are rewarded at the hourly wage rate of w_t, so pre-tax labor income equals $w_t h_t$.

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

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

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 an equal share of the firm's profit, $\Pi_t = \pi_t$. The budget constraint faced by an individual household is then

$$(1+\tau^c)c_t^i + k_{t+1}^i - (1-\delta)k_t^i = (1-\tau^y)[w_t h_t^i + r_t k_t^i + \pi_t] + g_t^t, \tag{3}$$

where τ^c is the tax rate on final consumption, τ^y is the proportional rate on labor and capital income, and g_t^t are per household government transfers.

In equilibrium, following the argument in Hansen (1985) and Rogerson (1988), only a proportion $n_t, 0 < n_t < 1$ of all households will be employed in each period (chosen at random by the employer, as all workers are identical from the perspective of the firm), which will denote the employment rate; note that the employment rate in the model is allowed to be time-varying. In addition, as in Rogerson and Hansen (1988) and King and Rebelo (2000), we no longer have full insurance, or

$$c_t^e = c_t^u(1-\bar{h})^{\frac{\psi}{\mu}-\psi}, \tag{4}$$

where c_t^e and c_t^u denote consumption levels of a worker and a non-worker, respectively, and where we have suppressed the i notation. Note that for $0 < \bar{h} < 1$, $\mu > 1$ and $\psi > 0$, $(1-\bar{h})^{\frac{\psi}{\mu}-\psi} > 1$. In other words, and employed individual would receive a higher consumption that that of an unemployed individual, $c_t^e > c_t^u$. As argued in Rogerson and Wright (1988), it can be also shown that the wage rate of an employed individual is higher than the marginal product of labor, hence the model will generate involuntary unemployment even in the absence of any other frictions in the labor market.

After aggregation over individual preferences, the aggregate household now features different preferences. It maximizes the following aggregate utility function

$$\max_{\{c_t,n_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{[c_t \phi(n_t)]^{1-\mu}}{1-\mu}, \tag{5}$$

where we have suppressed the u notation for consumption, and

$$\phi(n_t) = [n_t(1-\bar{h})^{\frac{\psi}{\mu}(1-\mu)} + (1-n_t)]^{\frac{1}{1-\mu}} \tag{6}$$

As in Maffezzoli (2001), the function above will be interpreted as the disutility of employment for the aggregate household. The elasticity of $\phi(.)$ with respect to employment is $\xi_\phi = \phi'(n)n/\phi(n)$.

Next, the aggregate household pools together all capital resources, and for $k_0^i = k_0, \forall i$, this produces the following aggregate budget constraint

$$(1+\tau^c)c_t + k_{t+1} - (1-\delta)k_t = (1-\tau^y)[w_t n_t \bar{h} + r_t k_t + \pi_t] + g_t^t. \tag{7}$$

As in Maffezzoli (2001), we will refer to this setup as the "Rogerson-Wright economy," or "RW," after Rogerson and Wright (1988). The Lagrangean of the aggregate household's problem is then

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^t \Bigg\{ \frac{[c_t \phi(n_t)]^{1-\mu}}{1-\mu} - \lambda_t \Bigg[(1+\tau^c)c_t + k_{t+1} - (1-\delta)k_t$$
$$-(1-\tau^y)[w_t n_t \bar{h} + r_t k_t + \pi_t] - g_t^t \Bigg] \Bigg\} \tag{8}$$

The first-order optimality conditions (FOCs) and the transversality condition are as follows:

$$c_t \;:\; c_t^{-\mu}[\phi(n_t)]^{1-\mu} = (1+\tau^c)\lambda_t \tag{9}$$

$$n_t \;:\; c_t^{1-\mu}[\phi(n_t)]^{-\mu} = \lambda_t(1-\tau^y)w_t \bar{h}, \tag{10}$$

$$k_{t+1} \;:\; \lambda_t = \beta E_t \lambda_{t+1}[1-\delta+(1-\tau^y)r_{t+1}] \tag{11}$$

$$TVC_k \;:\; \lim_{t\to\infty} \beta^t \lambda_t k_{t+1} = 0, \tag{12}$$

where λ_t is the Lagrangean multiplier attached to the aggregate household's period-t budget constraint. 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. The second equation determines the optimal employment, by balancing at the margin the cost and benefit from working. 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. The transversality conditions (TVCs) for physical capital is a boundary condition imposed to rule out explosive solutions.

2.2 Firm's problem

There is a representative firm in the economy, which produces a homogeneous product. The price of output is normalized to unity. The production technology is Cobb-Douglas and uses both physical capital, k_t, and labor hours, h_t, to maximize static profit

$$\Pi_t = A_t k_t^{\alpha}(n_t \bar{h})^{1-\alpha} - r_t k_t - w_t h_t, \tag{13}$$

where A_t denotes the level of technology in period t, $0 < \alpha, 1-\alpha < 1$ denote the capital and labor share, respectively.

Since the firm rents the capital from households, the problem of the firm is a sequence of static profit maximizing problems. In equilibrium, there are no profits, and each input is priced according to its marginal product, *i.e.*:

$$k_t \quad : \quad \alpha \frac{y_t}{k_t} = r_t, \tag{14}$$

$$n_t \bar{h} \quad : \quad (1-\alpha)\frac{y_t}{n_t \bar{h}_t} = w_t. \tag{15}$$

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

2.3 The Monopoly Union

In an alternative setup, which we refer to as "the monopoly union model," or "MU," the workers no longer individually choose their labor supply. In other words, the optimality condition for labor supply, Eq. (10), is no longer a part of the equilibrium system. Instead, the condition determining optimal employment will be obtained from the union problem described below. In this setup workers have decided that by organizing into a labor union, they can extract as a group some of the producer surplus. Here we take the presence of unions as an empirical regularity, and do not focus on the process of union formation itself. For example, Westermark (1999) shows that substitutable workers have an incentive to organize into unions, while complementary workers do not. In our model, the assumption of homogeneous households is thus equivalent to having a unit mass of perfectly substitutable workers. With everyone in the union, the organization is able to achieve complete diversification, and thus its preferences are risk-neutral.

The unions can be now aggregated into a representative union bargaining with the representative firm: the union and the firm will jointly determine the wage rate and the aggregate unemployment rate. In order to prevent union members who turn out to be unemployed ex post from leaving the union, the union has to provide a fair insurance against unemployment incidence. This is the approach in Maffezzoli (2001) and Benassy (1997), which allows us to abstract away from heterogeneity driven by the employment status. As a result, the marginal utility of consumption is equalized across employed and unemployed individuals, and the aggregation into a single aggregate household is possible.

The union is now a single seller of labor services behaves as a monopolist in the that market. As in Oswald (1982) and Palokangas (2000), the union's objective is to maximize the members' expected wage bill, or:

$$n_t w_t + (1 - n_t)\bar{w}_t, \tag{16}$$

s.t.

$$w_t = (1 - \alpha)\frac{y_t}{n_t \bar{h}_t}, \tag{17}$$

where n_t is the employment rate, and $\bar{w}_t$ denotes the unions' reservation wage, where the reservation wage can be viewed as the disutility of employment perceived by the unions, and inclusive of any type of unemployment benefits. As in Maffezzoli (2001), the sequence of reservation wages will be taken as being exogenous $\{\bar{w}_t\}_{t=0}^{\infty}$. The novelty in this paper is that the reservation wages will be responding to the state of the economy, or the level of total factor productivity. We believe this technical assumption to be a better description of reality, and in addition helps the model match data along the labor market dimension. The union also takes $\{k_t\}_{t=0}^{\infty}$ as given.

Note that the union takes as given the conditional labor demand of the representative firm, as well as the reservation wage. Once the wage rate is determined, firms choose the employment rate along the labor demand curve. This assumption is standard in this class of "monopoly union" setups, *e.g.* Dunlop (1944), Manning (1987), and Oswald (1982). Note that although a union is large at the firm or sector level, it is small at the aggregate level, and thus takes unions take r_t as given.

The union and the firm solve a sequence of independent games, due to the fact that (i) union takes the rental rate of capital as given; (ii) pre-commitment is ruled out, and (iii) the services of capital and labor are purchased in each period t. In the absence of credible pre-commitment, the union will not internalize the dynamic effect of today's wage on future investment, or the process of capital accumulation. In other words, investment in capital is inefficiently low, and the wage rate ia above its marginal product.

As in Maffezzoli (2001), and Anderson and Devereux (1988), we solve for the Markov equilibria, and more specifically, the focus is on Markov strategies depending only on current exogenous and endogenous state (predetermined) variables. The wage rate and the demand for capital will be jointly determined to form the Nash equilibrium of the game: the first two from the firm problem, while the employment will be determined from the union's maximization problem.

Substituting the expression for the wage from the firm's optimality condition, the union's welfare function can be rewritten as

$$n_t A_t k_t^{\alpha}(n_t\bar{h})^{1-\alpha} + (1-n_t)\bar{w}_t \tag{18}$$

Maximizing with respect to n_t results in

$$n_t = (1-\alpha)^2 \frac{y_t}{\bar{w}_t}, \tag{19}$$

or the monopoly employment rate is proportional to output and the reservation wage, which follows the dynamics of total factor productivity. As in the monopoly in the product market, here marginal revenue is also less than the price (wage), so employment chosen by the union and the firm is lower than the socially efficient level, hence there is involuntary unemployment. The corresponding union wage rate is then obtained from the firm's conditional labor demand function. Note that the aggregate wage function is positively, sloped, but its slope bears no relationship to the elasticity of the individual labor supply. The search-theoretic framework discussed in Hall (1998), and Vasilev (2016a) for the case of Bulgaria, feature the same property - an elastic aggregate wage-setting function, which is compatible with inelastic labor supply at the individual household level. Furthermore, the approach in this paper is also compatible with a search-theoretic model of the labor market. The same property was documented for the RW economy.

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 non-productive government purchases, and government transfers. The government budget constraint is as follows:

$$g_t^c + g_t^t = \tau^c c_t + \tau^y [w_t \bar{h} n_t + r_t k_t] \tag{20}$$

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

2.5 Dynamic Competitive Equilibrium (DCE)

For a given process followed by technology $\{A_t\}_{t=0}^{\infty}$, tax rates $\{\tau^c, \tau^y\}$, the fixed length of the work week $\bar{h}$, and initial capital stock $\{k_0\}$, the decentralized dynamic competitive equilibrium is a list of sequences $\{c_t, i_t, k_t, n_t\}_{t=0}^{\infty}$ for the household, a sequence of government purchases and transfers $\{g_t^c, g_t^t\}_{t=0}^{\infty}$, and input prices $\{w_t, r_t\}_{t=0}^{\infty}$ such that (i) the household maximizes its utility function subject to its budget constraint; (ii) the representative firm maximizes profit; (iii) in the union model, the union maximizes its objective function subject to the conditional demand for labor; (iv) government budget is balanced in each period; (v) all markets clear.

3 Data and Model Calibration

To characterize business cycle fluctuations in Bulgaria, we will focus on the period following the introduction of the currency board (1999-2016). Quarterly data on output, consumption and investment was collected from National Statistical Institute (2017), while the real interest rate is taken from Bulgarian National Bank Statistical Database (2017). The calibration strategy described in this section follows a long-established tradition in modern macroeconomics: first, as in Vasilev (2016), the discount factor, $\beta = 0.982$, is set to match the steady-state capital-to-output ratio in Bulgaria, $k/y = 13.964$, in the steady-state Euler equation. The capital share, $\alpha = 0.429$, was estimated as in Vasilev (2017d). Next, the average income tax rate was set to $\tau^y = 0.1$. This is the average effective tax rate on income between 1999-2007, when Bulgaria used progressive income taxation, and equal to the proportional income tax rate introduced as of 2008. Similarly, the average tax rate on consumption is set to its value over the period, $\tau^c = 0.2$.

The value of the curvature parameter of the utility function is set to $\mu = 2$, which is a standard value in the literature. The the relative weight attached to the utility out of leisure in the household's utility function, $\psi = 2$, is calibrated to match that in steady-state consumers would supply one-third of their time endowment to working. This is in line with the estimates for Bulgaria (Vasilev 2017a) as well over the period studied. This calibration produces a value of the elasticity of the disutility of unemployment, $\xi_\phi = 0.757$. Employment rate, $n = 0.533$, was also set to its average value over the period studied.

Next, the steady-state depreciation rate of physical capital in Bulgaria, $\delta = 0.013$, was taken from Vasilev (2016). It was estimated as the average quarterly depreciation rate over the period 1999-2014. Finally, the processes followed by TFP processes and energy prices, are estimated from the detrended series by running an AR(1) regression and saving the residuals. Table 1 below summarizes the values of all model parameters used in the paper.

Table 1: Model Parameters

Parameter	Value	Description	Method
β	0.982	Discount factor	Calibrated
α	0.751	Relative capital Share	Data average
μ	2.000	Curvature parameter, utility function	Set
ψ	2.000	Relative weight attached to leisure	Calibrated
δ	0.013	Depreciation rate on physical capital	Data average
n	0.533	Employment rate	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

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. Both models produce the same steady-state; the results are reported in Table 2 below. The steady-state level of output was normalized to unity (hence the level of technology A differs from one, which is usually the normalization done in other studies), which greatly simplified the computations. Next, the models government purchases ratios by construction; The match consumption-to-output and investment ratio is also closely approximated, despite the closed-economy assumption and the absence of foreign trade sector. The shares of income are also identical to those in data, which is an artifact of the assumptions imposed on functional form of the aggregate production function. The after-tax return, where $\bar{r} = (1 - \tau^y)r - \delta$ is also relatively well-captured by the model.

5 Out of steady-state model dynamics

Since both models do not have an analytical solution for the equilibrium behavior of variables outside their steady-state values, we need to solve the models numerically. This is done by

Table 2: Data Averages and Long-run Solution

Variable	Description	Data	Model (RW&MU)
y	Steady-state output	N/A	1.000
c/y	Consumption-to-output ratio	0.648	0.674
i/y	Investment-to-output ratio	0.201	0.175
k/y	Capital-to-output ratio	13.96	13.96
g^c/y	Government consumption-to-output ratio	0.151	0.151
$wn\bar{h}/y$	Labor income-to-output ratio	0.571	0.571
rk/y	Capital income-to-output ratio	0.429	0.429
$\bar{h}$	Share of time spent working	0.333	0.333
$\bar{r}$	After-tax net return on capital	0.014	0.016

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 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

This subsection documents the impulse responses of model variables to a 1% surprise innovation to technology. The impulse response functions (IRFs) are presented in Figs. 2 and 3 and on the next page. For expositional purposes, the two models (RW and MU) are presented separately. As a result of the one-time unexpected positive shock to total factor productivity, output increases upon impact. This expands the availability of resources in the economy, so used of output - consumption, investment, and government consumption 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 representative households then respond to the incentives contained in prices and start accumulating 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.

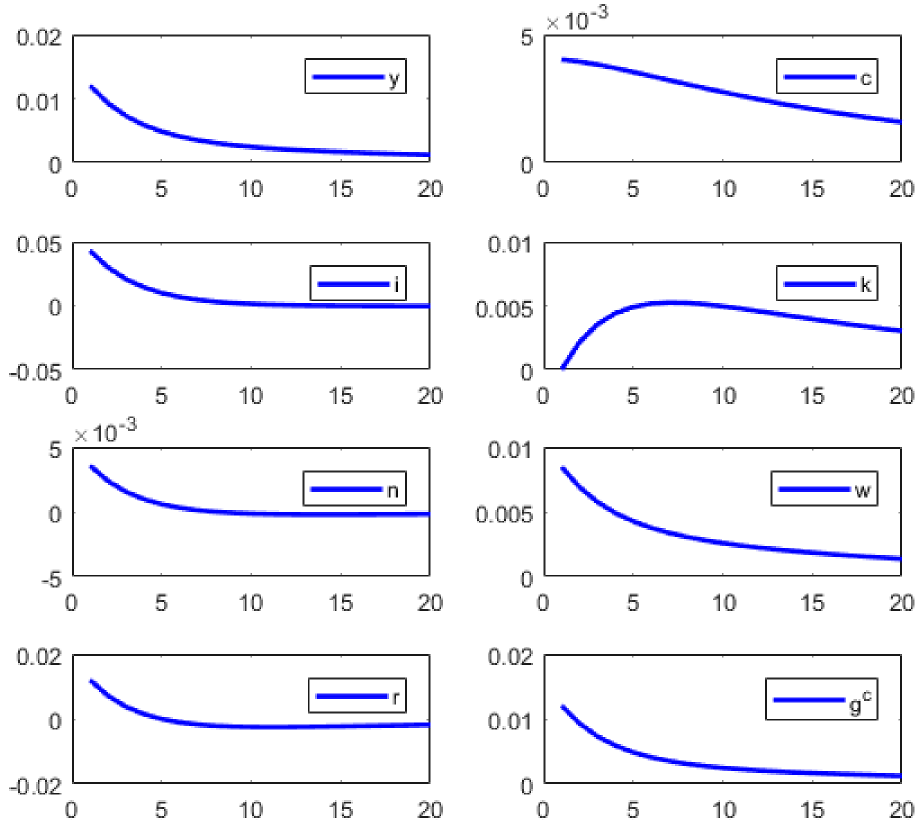

Figure 2: Impulse Responses to a 1% surprise innovation in technology, RW model

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. In the case of the union model, the effect of the technology shock is shor-lived due to the fact that the union does

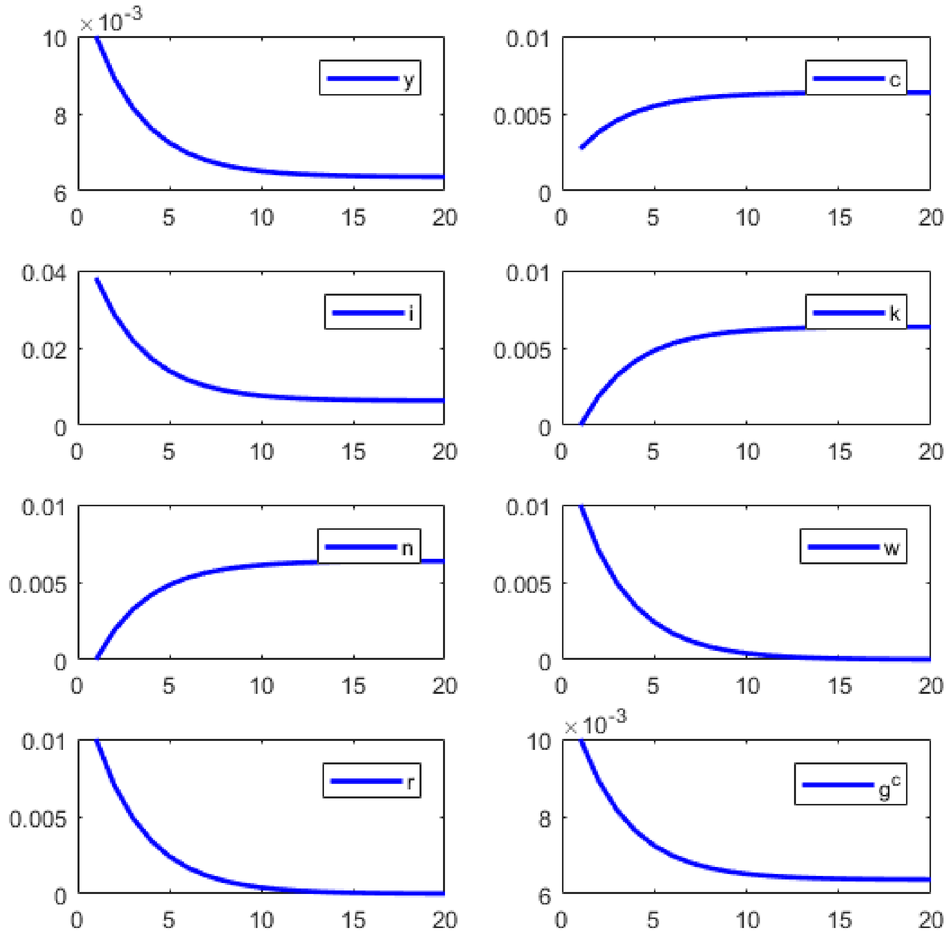

Figure 3: Impulse Responses to a 1% surprise innovation in technology, MU model

not internalize the capital externality. In other words, the sequential bargaining between the union and the firm now is a major internal mechanism, which quantitatively dominates the work of the capital accumulation. Note that with unions there is no intra-temporal optimality between consumption and labor, as the household no longer individually determines its labor supply. The two modesl also produce different dynamics for the wage rate, in the RW economy, it follows a hump shape, while in the union model it converges monotonically.

5.2 Simulation and moment-matching

As in Vasilev (2017b), 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 quarterly frequency.To minimize the sample error, the simulated moments are averaged out over the computer-generated draws. As in Vasilev (2016, 2017b, 2017c), both models match quite well the absolute volatility of output; By construction, government consumption in the model varies as much as output. In addition, the predicted consumption volatilies are a bit too high, where the increase in consumption variability in the union could be attributed to the collective bargaining mechanism. Still, the model is qualitatively consistent with the stylized fact that consumption generally varies less than output, while investment is more volatile than output. Again, the union model is closer to data in terms of the magnitude of the empirical investment volatility. With union in the model, the quantitative importance of capital accumulation is lower, thus investment variability is depressed.

With respect to the labor market variables, the variability of employment predicted by the model is lower than that in data in RW setup, and higher in the MU model. On the other hand, the variability of wages in the model is very close to that in data for the RW economy, and a bit too low in the MU model. This is yet another confirmation that the perfectly-competitive assumption, *e.g.* Vasilev (2009), as well as the benchmark calibration of the RW model with indivisible labor here, does not describe very well the dynamics of labor market variables, even in the presence of unions. However, it takes an infinite elasticity of labor supply, as in the RW setup, to generate the right amount of wage volatility.

Next, in terms of contemporaneous correlations, the models systematically over-predicts the pro-cyclicality of the main aggregate variables - consumption, investment, government consumption, and employment. This, however, is a common limitation of this class of models. With respect to wages, the RW setup predicts a strong cyclicality, while wages in data are acyclical. This shortcoming is well-known in the literature and an artifact of the wage

Table 3: Business Cycle Moments

	Data	Model RW	MU Model
σ_y	0.05	0.05	0.05
σ_c/σ_y	0.55	0.76	0.95
σ_i/σ_y	1.77	2.34	1.56
σ_g/σ_y	1.21	1.00	1.00
σ_n/σ_y	0.63	0.17	0.95
σ_w/σ_y	0.83	0.88	0.33
$\sigma_{y/h}/\sigma_y$	0.86	0.88	0.33
$corr(c,y)$	0.85	0.92	0.95
$corr(i,y)$	0.61	0.89	0.79
$corr(g,y)$	0.31	1.00	1.00
$corr(n,y)$	0.49	0.72	0.91
$corr(w,y)$	-0.01	0.99	0.31

being equal to the labor productivity in the model. The union model provides a better description, as it only predicts only a moderate procyclicality. The correlation of wages and output drops to zero if the reservation wage does not respond to productivity shocks. Maffezzoli (2001) does not report the volatility of wages in his calibration for Italy, but from the impulse responses it can be seen that his model suffers from very low wage variability as well. This is a success for the MU models, since, after all, not all of the Bulgarian economy is unionized, and most of the collective bargaining is happens at a firm level.

In the next subsection, as in Vasilev (2016), 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 two competing models.

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 Tables 4 and 5 below against the averaged simulated AFCs and CCFs. Following Canova (2007), this is used as a goodness-of-fit measure. Both models compare 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 and household consumption are well-approximated by the model. The persistence of labor market variables are also relatively well-described by the model dynamics. Overall, both models generate too much persistence in output and both employment and unemployment, and is subject to the criticism in Nelson and Plosser (1992), Cogley and Nason (1995), Rotemberg and Woodford (1996), and Hall (1999), who argue that the RBC class of models do not have a strong internal propagation mechanism besides the strong persistence in the TFP process. In those models, *e.g.* the RW setup, labor market is modelled in the Walrasian market-clearing spirit, and output and unemployment persistence is low. Indeed, when unions are allowed in the model, the MU setup is marginally better than the RW in terms of autocorrelations. A similar picture can be observed in the cross-correlations.

Table 4: Autocorrelations for Bulgarian data and the RW 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 RW	$corr(u_t, u_{t-k})$	1.000	0.954	0.897	0.831
	(s.e.)	(0.000)	(0.028)	(0.054)	(0.071)
Data	$corr(n_t, n_{t-k})$	1.000	0.484	0.009	0.352
Model RW	$corr(n_t, n_{t-k})$	1.000	0.954	0.897	0.831
	(s.e.)	(0.000)	(0.028)	(0.054)	(0.071)
Data	$corr(y_t, y_{t-k})$	1.000	0.810	0.663	0.479
Model RW	$corr(y_t, y_{t-k})$	1.000	0.957	0.906	0.848
	(s.e.)	(0.000)	(0.026)	(0.050)	(0.072)
Data	$corr(a_t, a_{t-k})$	1.000	0.702	0.449	0.277
Model RW	$corr(a_t, a_{t-k})$	1.000	0.954	0.900	0.837
	(s.e.)	(0.000)	(0.028)	(0.053)	(0.077)
Data	$corr(c_t, c_{t-k})$	1.000	0.971	0.952	0.913
Model RW	$corr(c_t, c_{t-k})$	1.000	0.958	0.909	0.855
	(s.e.)	(0.000)	(0.024)	(0.047)	(0.069)
Data	$corr(i_t, i_{t-k})$	1.000	0.810	0.722	0.594
Model RW	$corr(i_t, i_{t-k})$	1.000	0.955	0.900	0.836
	(s.e.)	(0.000)	(0.028)	(0.053)	(0.077)
Data	$corr(w_t, w_{t-k})$	1.000	0.760	0.783	0.554
Model RW	$corr(w_t, w_{t-k})$	1.000	0.957	0.907	0.851
	(s.e.)	(0.000)	(0.025)	(0.049)	(0.071)

Table 5: Autocorrelations for Bulgarian data and the MU 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 MU	$corr(u_t, u_{t-k})$	1.000	0.954	0.905	0.852
	(s.e.)	(0.000)	(0.021)	(0.041)	(0.060)
Data	$corr(n_t, n_{t-k})$	1.000	0.484	0.009	0.352
Model MU	$corr(n_t, n_{t-k})$	1.000	0.954	0.905	0.852
	(s.e.)	(0.000)	(0.021)	(0.041)	(0.060)
Data	$corr(y_t, y_{t-k})$	1.000	0.810	0.663	0.479
Model MU	$corr(y_t, y_{t-k})$	1.000	0.954	0.903	0.849
	(s.e.)	(0.000)	(0.023)	(0.045)	(0.065)
Data	$corr(a_t, a_{t-k})$	1.000	0.702	0.449	0.277
Model MU	$corr(a_t, a_{t-k})$	1.000	0.955	0.901	0.838
	(s.e.)	(0.000)	(0.027)	(0.053)	(0.077)
Data	$corr(c_t, c_{t-k})$	1.000	0.971	0.952	0.913
Model MU	$corr(c_t, c_{t-k})$	1.000	0.954	0.905	0.851
	(s.e.)	(0.000)	(0.021)	(0.042)	(0.061)
Data	$corr(i_t, i_{t-k})$	1.000	0.810	0.722	0.594
Model MU	$corr(i_t, i_{t-k})$	1.000	0.954	0.901	0.841
	(s.e.)	(0.000)	(0.026)	(0.051)	(0.074)
Data	$corr(w_t, w_{t-k})$	1.000	0.760	0.783	0.554
Model MU	$corr(w_t, w_{t-k})$	1.000	0.955	0.901	0.838
	(s.e.)	(0.000)	(0.027)	(0.053)	(0.077)

Next, as seen from Table 6 below, over the business cycle, in data labor productivity leads employment. The RW model, however, cannot account for this fact. 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. In contrast, the model with a monopoly

Table 6: Dynamic correlations for Bulgarian data and the RW 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
RW	$corr(n_t, (y/n)_{t-k})$	0.023	0.023	0.024	0.621	0.065	0.029	0.004
	(s.e.)	(0.336)	(0.292)	(0.239)	(0.224)	(0.215)	(0.259)	(0.030)
Data	$corr(n_t, w_{t-k})$	0.355	0.452	0.447	0.328	-0.040	-0.390	-0.57
RW	$corr(n_t, w_{t-k})$	0.023	0.023	0.024	0.621	0.065	0.029	0.004
	(s.e.)	(0.336)	(0.292)	(0.239)	(0.224)	(0.215)	(0.259)	(0.030)

union, where the wage is determined via a sequantial bargaining procedure between the firm and the union, is able to match the low contemporaneous correlation between hours and wages, as well as the general dynamic pattern at various leads and lags. This is yet another indication that the presence of unions and collective agreements is important for the observed dynamics in the labor market in Bulgaria for the period after the introduction of the currency board.

6 Conclusions

In this paper we investigate the quantitative importance of collective agreements in explaining fluctuations in Bulgarian labor markets. We introduce collective bargaining between a representative union and a representative firm into a real-business-cycle setup augmented with a detailed government sector. We calibrate the model to Bulgarian data for the period following the introduction of the currency board arrangement (1999-2016), and compare and contrast it to a model with indivisible labor and no unions as in Rogerson and Wright (1988).

Table 7: Dynamic correlations for Bulgarian data and the MU 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
MU	$corr(n_t, (y/n)_{t-k})$	-0.045	-0.043	-0.036	-0.030	0.028	0.038	0.043
	(s.e.)	(0.326)	(0.289)	(0.250)	(0.453)	(0.280)	(0.339)	(0.388)
Data	$corr(n_t, w_{t-k})$	0.355	0.452	0.447	0.328	-0.040	-0.390	-0.57
MU	$corr(n_t, w_{t-k})$	-0.045	-0.043	-0.036	-0.030	0.028	0.038	0.043
	(s.e.)	(0.326)	(0.289)	(0.250)	(0.453)	(0.280)	(0.339)	(0.388)

We find that the sequential bargaining between unions and firms produces an important internal propagation mechanism, which fits data much better that the alternative framework with indivisible labor.

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