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Search and Matching Frictions and Business Cycle Fluctuations in Bulgaria

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Abstract

This research investigates the quantitative importance of search and matching frictions in Bulgarian labor market, by augmenting an otherwise standard real business cycle a la Long and Plosser (1983) with a two-sided costly search and fiscal policy. This strong propagation mechanism allows the model to capture the business cycles in Bulgaria better than earlier models. The model performs well with the given data, especially along the labor market dimension, and dominates the market-clearing labor market framework featured in the standard RBC model, e.g. Vasilev (2009), as well as the indivisible labor market extension in Hansen (1985).

Key words: General Equilibrium, Unemployment and Wages, Business Cycle, Fiscal Policy

JEL classification: D51; E24; E32; J40.

1. Introduction

The standard real business cycle model with a perfectly-competitive labor market is unable to capture the dynamics in the Bulgarian labor market (Vasilev 2009). More specifically, the setup is unable to explain the presence of involuntary unemployment and cannot generate the so-called "Beveridge curve", which denotes a strong negative relationship between open positions (vacancies) and unemployment. Several researchers propose that the failure of standard RBC models (e.g. Kydland and Prescott (1982) and Long and Plosser (1983) for the US and Vasilev (2009) for Bulgaria to adequately capture labor market dynamics might necessitate abandoning the Walrasian frictionless market-clearing labor market paradigm. Using a setup with real frictions, Diamond (1982) and Pissarides (1985) show the relevance of a search-and-matching model in macroeconomic context when the separation rate is taken to be exogenous. Our paper utilizes that search-and-matching framework and aims to model the labor market in Bulgaria after the currency board introduction (1997) in an equilibrium business cycle model with fiscal policy. The two-sided costly search and matching frictions create an inefficient outcome in the labor market due to search and congestion externalities. In the model, search and recruiting activities are viewed as

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costly investment activities that help eventually augment the number of jobs created ("matches"), in turn increasing total employment. Similarly, the vacancies that are posted by employers could be viewed as an asset that brings value when the position is filled with a suitable candidate. With trade frictions in the market for labor, the search effort is sub-optimal, resulting in labor input being rationed. Since this rationing is stochastic (due to the limited information about candidates in the market and available positions), the price, i.e., the wage rate, is not the only allocative mechanism. Therefore, wage adjustments alone cannot eliminate inefficiency.

On the worker side, working is generally more valuable than being unemployed. However, under certain conditions, unemployment maybe an optimal outcome, if it is not to the worker's or the employer's advantage to continue the employment contract. Thus, the model is able to produce involuntary unemployment in equilibrium. More specifically, in each period matches are destroyed with some exogenous probability, and any employed person faces risk of being laid off. The process of trading the labor input in an environment featuring imperfect information, or equivalently the search and matching frictions present in the labor market, provides a tractable mechanism that is both realistic and plausible.

This paper proceeds to evaluate the quantitative importance of search and matching frictions in the case of Bulgaria's business cycles. Those real rigidities introduce history dependence in the employment status, which makes employment, unemployment, and output more persistent. Such real rigidities could represent a quantitatively important propagation mechanism that can replicate data behavior, especially along the labor market dimension. Overall, the search and matching model and trade frictions generate persistence in output and both employment and unemployment and are able to address the criticism in Nelson and Plosser (1992), Cogley and Nason (1995), and Rotemberg and Woodford (1996), who argue that the RBC model does not have a strong internal propagation mechanism besides the strong persistence in the TFP process. As in Andolfatto (1996), incorporating search and matching frictions pushes 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 Nash-bargaining procedure. Finally, the dynamic correlation between vacancies and unemployment in Bulgaria is also well-captured by the model.

The rest of the paper is organized as follows. Section 2 describes the model setup. Section 3 outlines the model parameterization and the calibration strategy employed. Section 4 presents the steady-state results. Section 5 discusses the impulse responses, compares simulated to empirical moments, and evaluates the model's overall goodness-of-fit. Section 6 concludes.

2. Model Setup

The structure of the model economy runs as follows. There is a unit mass of households as well as a representative firm. The households own physical capital and labor, which are supplied to the firm. Aggregate employment depends on both the probability of matching and the search effort of households. There is a representative firm using a constant-returns-to-scale technology. The firm produces output using labor and capital. It posts a vacancy to advertise an available position. Thus, the labor market is characterized by a costly two-sided search. The wage rate is decided via a Nash bargaining procedure. The government uses tax revenues from labor and capital income to finance non-productive government consumption and lump-sum government transfers.

2.1 Households

Each homogeneous one-member household derives utility out of consumption and leisure

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \{\ln C_t + \phi \ln(1 - N_t)\}, \tag{2.1}$$

where E_0 denotes the expectations operator as of time 0, C_t, N_t denote consumption and hours (employment) in period t, $0 < \beta < 1$ is the discount factor, and $\phi > 0$ denotes the relative wei weight attached to leisure in the households' utility. As in Merz (1995) and Andolfatto (1996), households pool together all resources and in this way achieve full insurance against the contingency of unemployment. As a result, consumption is identical across households regardless of the employment status.

Households own the capital, which evolves according to the following law of motion:

$$K_{t+1} = I_t + (1 - \delta)K_t \tag{2.2}$$

where $0<\delta<1$ is the depreciation rate. Households loan capital to the firm at rate r_t, generating $r_t K_t$ in before-tax capital income. Yet another source of income for households is labor income. Aggregate employment evolves as follows:

$$N_{t+1} = (1 - \psi)N_t + p_t S_t (1 - N_t) \tag{2.3}$$

where $0 \leq \psi \leq 1$ denotes the transition rate from employment to unemployment, and $p_t \geq 0$ denotes the probability of a match in period t, which depends on tightness in the labor market. Households take as given the probability p_t at which the aggregate search effort produces a match. Aggregate before-tax labor income is then $w_t N_t$, where w_t is the hourly wage rate in the economy.

Households can decide to use time and effort to improve their chances of forming a match. As in Merz (1995), we assume the search cost function is monotone in search intensity and of the form:

$$b_0 S_t^{\eta}(1 - N_t), \tag{2.4}$$

where $b_0 > 0, \eta \geq 1, S_t>0$. That is, the cost of searching for a job is $b_0 S_t^{\eta}$ per household, and the mass of unemployment is 1-N. Since search cost produces a waste of resources in the economy, total search cost will be accounted for as an output cost. Since search cost produces a waste of resources in the economy, total search cost will be accounted for as an output cost. Households own the firm in the economy and claim all the profit. Households' budget constraint is then:

$$\begin{aligned} C_t + K_{t+1} - (1-\delta)K_t + b_0 S_t^{\eta}(1 - N_t) \\ = (1-\tau^k)r_t K_t + (1-\tau^l)w_t N_t + \Pi_t + G_t^{tr} \end{aligned} \tag{2.5}$$

where $\{\tau^k, \tau^l\}$ are the respective average effective tax rates on capital and labor income, Π_t denote a firm's aggregate profits, and G^{tr} are government transfers. Taking the tax rates $\{\tau^k, \tau^n\}$, prices $\{w_t, r_t\}_{t=0}^{\infty}$, profit $\{\Pi_t\}_{t=0}^{\infty}$, government transfers $\{G^{tr}\}_{t=0}^{\infty}$, the process followed by total factor productivity $\{A_t\}_{t=0}^{\infty}$ and initial conditions for capital K_0, employment N_0, and technology A_0 as given, households choose aggregate allocations $\{C_t, N_{t+1}, S_t, K_{t+1}\}_{t=0}^{\infty}$ to maximize (2.1) s.t. (2.2)-(2.5). The resulting first-order optimality conditions (FOCs) and the transversality condition (TVC) are as follows:

$$C_t: \ \frac{1}{C_t} = \lambda_t \tag{2.6}$$

$$K_{t+1}: \ \lambda_t = \beta E_t \lambda_{t+1}[(1-\tau^k)\alpha \frac{Y_{t+1}}{K_{t+1}} + (1-\delta)] \tag{2.7}$$

$$S_t: \ \lambda_t b_0 \eta S_t^{\eta-1} = \mu_t p_t \tag{2.8}$$

$$N_{t+1}: \frac{b_0 \eta S_t^{\eta-1}}{C_t}$$

$$= p_t \beta E_t \left\{ \begin{matrix} \frac{1}{C_{t+1}}\left[(1-\tau^l)w_{t+1} + b_0 S_{t+1}^{\eta}\right] + \\ \frac{\phi}{1-N_{t+1}} + \frac{b_0 \eta S_{t+1}^{\eta-1}}{C_{t+1} p_{t+1}}[1-\psi - p_{t+1} S_{t+1}] \end{matrix} \right\} \tag{2.9}$$

$$TVC: \lim_{t\to\infty} \lambda_t K_{t+1} = 0 \tag{2.10}$$

Here, λ_t and μ_t are the Lagrangean multipliers of the budget constraint and employment dynamics, respectively. The first-order optimality conditions obtained above have standard interpretations. The first is the optimality condition for consumption, which requires that the marginal utility from consumption equals the marginal utility of wealth. The second is the so-called Euler condition, which describes how households choose capital in two congruent periods in order to smooth consumption.

The static optimality condition for the search effort balances the costs and benefits from searching for a job. A similar logic applies to employment. We can think of it as determining the labor supply. However, in this case choosing employment is a dynamic problem, as the value of a match extends to more than that one period. Each unemployed household chooses the level of search effort in order to balance the costs and benefits at the margin. The benefit is the discounted payoff from the labor income and the foregone search cost minus the disutility from working. As in Merz (1995), this benefit is conditioned on "any additional search effort leading to a job match with probability p_t." Here, TVC is a boundary condition on capital, which guarantees that explosive solutions are ruled out.

2.2 Stand-in Firm

There is a representative firm in the set-up using a Cobb-Douglas production function, which uses both capital and labor:

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha} \tag{2.11}$$

where $0 < \alpha < 1$ measures capital share. With search externalities, $1 - \alpha$ is no longer the labor share; still, the production function features constant returns to scale. The firm chooses how much capital to rent, how many to employ, and how many vacancies to advertise. Its problem now becomes dynamic due to the value of the match, and the fact that if a vacancy is filled, then the firm can economize on advertising the position.

The advertising cost incurred equals aV_t, $a > 0$. This is considered as part of production costs and thus will be deducted from the firm's profit. The firm takes the dynamics of aggregate employment as a constraint when maximizing its discounted profit:

$$N_{t+1} = (1-\psi)N_t + q_t V_t \tag{2.12}$$

The firm takes the endogenous probability that a vacancy is filled, $\{q_t\}$, as given.

$$\text{FOCs:} \quad K_t: \ \alpha \frac{Y_t}{K_t} = r_t \tag{2.13}$$

$$N_t: \ \beta_t \left[(1-\alpha)\frac{Y_{t+1}}{N_{t+1}} - w_{t+1} + \frac{a(1-\psi)}{q_{t+1}}\right] = \frac{a}{q_t} \tag{2.14}$$

The first one is the usual optimality condition for capital, implying that the input is prized at its marginal product. The optimality condition for labor is different from the one in standard RBC models. The literature refers to the second optimality condition as the job creation condition (JCC). On the right-hand side is the effective cost of a vacancy, which is the product of the advertising cost per opened vacancy, a, and the expected time on average that this vacancy stays unfilled, $1/q_t$. The expression on the left-hand side is the expected discounted benefit from a vacancy: when filled, the return to the firm is the difference between the marginal product of labor less the wage, plus the saved cost on not advertising a vacancy, weighted by the probability of the match not being discontinued.

2.3 Matching Technology

We assume aggregate job matches are generated by the following production function:

$$M_t = V_t^{1-\gamma}[S_t(1-N_t)]^{\gamma} \tag{2.15}$$

where $0 \leq \gamma \leq 1$ measures the elasticity of job matches with respect to search effort, and V_t is the number of vacancies available in period t. This type of modeling is based on the empirical findings of Blanchard and Diamond (1989) and Pissarides (1986). Mortensen (1982) and Hosios (1990) also argue that search effort should be included as in input in the aggregate matching function, and hence the specification used above. This type of modeling matches as described above implies endogenous probabilities for the transition from unemployment to employment, defined as:

$$p_t = \frac{M_t}{S_t(1-N_t)} = \left(\frac{\theta_t}{S_t}\right)^{1-\gamma} \tag{2.16}$$

Where $\theta_t = \frac{V_t}{1-N_t} = \frac{V_t}{U_t}$ (2.17)

Represents the tightness of the market. More specifically, when the market is tight, the probability of finding a job (and filling a position) will be low. Thus, the job-finding rate can be expressed as a function of the tightness, or

$$p(\theta_t) = \frac{M_t}{U_t} = \left(\frac{\theta_t}{S_t}\right)^{1-\gamma} \tag{2.18}$$

That is, the probability of making a transition from being unemployed to becoming employed decreases with the congestion caused by either increase in unemployment or the search effort. Lastly,

$$q_t = \frac{M_t}{V_t} = \left(\frac{S_t}{\theta_t}\right)^{\gamma} \tag{2.19}$$

is the transition probability from an unfilled vacancy to a filled one. It is increasing in the search effort, the amount of vacancies and unemployment, and decreasing in market tightness, since

$$q(\theta_t) = \left(\frac{S_t}{\theta_t}\right)^{\gamma} \tag{2.20}$$

Alternatively, the inverse of the transition probability from unemployment to employment,

$$\frac{1}{q_t} = \frac{1}{q(\theta_t)} \tag{2.21}$$

can be interpreted as the expected duration of a vacancy.

2.4 Wage Determination

One can determine the wage rate as an outcome from a Nash bargaining protocol, where the worker and the firm negotiate over the distribution of the rents arising from the value of the match. In technical terms, we have

$$w_t = argmax[W_t - U_t]^{\lambda}[J_t - Q_t]^{1-\lambda} \tag{2.22}$$

where the surplus to the household is the difference between W_t, the value to the household from being employed, and U_t, the value when unemployed. From the employer's perspective, the surplus from the match is the difference between the value J_t from filling a vacancy and Q_t as the value from an unfilled vacancy. It is a standard result (Shimer 2010) that the wage rate obtained is

$$w_t = \lambda\left[(1-\alpha)\frac{Y_t}{N_t} + a\frac{V_t}{1-N_t}\right] + (1-\lambda)\left[-\frac{\phi C_t}{1-N_t} - b_0 S_t^{\eta}\right]$$

The Hosios (1990) condition in the static context, and extended by Merz (1995) to dynamic settings, $\gamma = \lambda$, produces perfect insurance markets and efficiency in the outcome of the wage-employment contracts. By setting the bargaining weights equal to the corresponding elasticities in the matching function, the Hosios condition internalizes the search externalities.

$$w_t = \gamma\left[(1-\alpha)\frac{Y_t}{N_t} + a\frac{V_t}{1-N_t}\right] + (1-\gamma)\left[-\frac{\phi C_t}{1-N_t} - b_0 S_t^{\eta}\right]$$

The expression above is also known as a wage schedule, or a "wage curve," as documented in Blanchflower and Oswald (1994). A job is an asset owned by the firm, and hence the optimality condition for vacancy is akin to an asset price equation. More specifically, a vacant job costs aV and changes state according to a process. Given perfectly-competitive capital markets, there will not be any capital gains/losses from expected changes in the valuation of the jobs/match. The firm compares expected profit from an occupied job versus the expected profit from a vacant job. The wage rate is the weighted average of the marginal product of labor and the marginal rate of substitution between consumption and hours, where the latter can be regarded as a worker's outside opportunity. The weights correspond to the relative bargaining power in the wage negotiation process. With endogenous search effort, we also have a weighted average of the marginal benefit from searching and the marginal cost of searching. If the worker is employed, then s/he can save on searching, as there will be no need to re-engage in any search effort.

As Merz (1995) suggests, we can think of the wage expression as representing the two "threat points" in the wage negotiations.[25] On the one hand, the household asks for the value of its marginal product less the cost of advertising borne by the firm. The firm, however, will only be willing to pay the worker's reservation wage, which equals the marginal disutility of work less the search cost incurred. Thus, the equilibrium wage rate is a weighted average of the two, whereby the elasticity of the matching function with respect to the households' total search effort $S_t(1 - N_t)$ could be regarded also as the households' bargaining strength.

2.5 Government

The government levies taxes on both capital and labor income to finance non-productive government consumption and the lump-sum transfer. The budget constraint is balanced in every period.

$$\tau^k r_t K_t + \tau^l w_t N_t = G_t^c + G_t^{tr} \qquad (2.26)$$

where G^c denotes wasteful government spending. The spending-to-output ratio $G^{cy}=G^c/Y$ is set equal to its data average, so that the level of spending will vary with output (since $G^c = G^{cy} Y_t$). Government transfers are residually determined, as they are allowed to vary so that the government budget constraint is balanced in every period.

2.6 Decentralized Competitive Equilibrium (DCE) with Search Externalities

Given the total factor productivity (TFP) process $\{A_t\}_{t=0}^{\infty}$, the two tax rates $\{\tau^l, \tau^k\}$, and the initial conditions for the (endogenous and exogenous) state variables k_0, A_0, we define a Decentralized Competitive Equilibrium (DCE) with search as a sequence of prices and allocations such that (i) expected utility is maximized; (ii) the stand-in firm maximizes dynamic profit; (iii) the wage rate is determined as an outcome from Nash bargaining between the households and the firm; (iv) government budget is balanced in each time period; (v) all markets clear.

3. Data and Model Calibration

We calibrate the model to Bulgarian data at quarterly frequency. The period under investigation is 2000-2016, and we obtain quarterly data on output, household and government consumptions, private fixed investment shares in output, employment rate, unemployment rate, and vacancy rate from the National Statistical Institute (2018). Following Vasilev (2015), we obtain the capital income share to its average value α = 0.429, and the labor income share is $1 - \alpha = 0.571$. Next, we use Vasilev's (2017a,b) estimate that the annual depreciation rate on physical capital is 5%, which in our quarterly model corresponds to $\delta = 0.0125$. The annual estimates of the average capital stock to output reported in Vasilev (2015) are then converted to quarterly ones, thus obtaining $K/Y = 13.964$. This gives us sufficient information to calibrate the discount factor from the steady-state Euler equation.

We set the relative weight on leisure in the household's utility function, parameter $\varphi = 1.803$, to match the steady-state employment rate in Bulgaria over the period, n = 0.533. Next, we normalize steady-state output to unity, which produces $A = 0.605$. Burda (1997) estimates $m/n = 0.009$ for Bulgaria, which yields $\psi = 0.009$. The scale parameter of the search cost function is $b_0 = 0.001$, which is of the magnitude chosen in Merz (1995).[28] Similarly, due to a lack of information, we assume linear search costs and set $\eta = 1$. Again, the curvature of the search cost function does not affect our results quantitatively. Following Aldolfatto (1996), for the advertising costs we set per vacancy cost $a = 0.1$.[29] Since the shares of the search and recruiting costs in output in the next section turn out to be very small, the size of the scale parameters is of little importance when it comes to the model dynamics over the business cycle. Next, the elasticity of job matches with respect to search effort and usually estimated from the matching function. However, given the short series available for Bulgaria, we adopt $\lambda = \gamma = 0.4$ from Blanchard and Diamond (1990) and Petrolongo and Pissarides (2001).

We finally estimate the parameters for the total factor productivity process by obtaining the Solow residuals from the Cobb-Douglas production function using data on output, capital and employment, as well as estimated capital share. Next, we detrend the Solow residuals using the Hodrick-Prescott (1980) filter. Through the now made-stationary series, we estimate an AR(1) model with Ordinary Least Squares (OLS), producing consistent estimates $\hat{\rho}_a = 0.7$ with $s.e.(\hat{\rho}_a) = 0.117$ and $\hat{\sigma}_a$ = 0.044, which we utilize in the simulation stage. Table 1 below summarizes the values of model parameters used in this paper.

Table 1. Model Parameters

Parameter	Value	Description	Method
β	0.982	Discount Factor	Calibrated
α	0.429	Capital Share in Output	Data Avg.
δ	0.013	Depreciation Rate	Data Avg.
φ	1.803	Weight Attached to Utility of Leisure	Calibrated
η	1.000	Curvature of the Search Cost Function	Calibrated
γ	0.400	Elasticity of Job Matches W.R.T Search Effort	Calibrated
$1-\gamma$	0.600	Elasticity of Job Matches W.R.T. Vacancies	Calibrated
ψ	0.009	Transition Rate from Empl. to Unempl.	Data Avg.
a	0.100	Per-Unit Advertising Costs	Set
b_0	0.001	Scale Parameter, Search Cost Function	Set
A	0.604	Steady-State Value of TFP	Calibrated
ρ_a	0.701	AR(1) Persistence Coefficient, TFP Process	Estimated
σ_a	0.044	St. Error, TFP Process	Estimated

4. Steady-State

Once we obtain the model parameters, we can get the steady-state ratios for the model calibrated to Bulgarian data. Table 2 lists the results below. Overall, the long-run behavior of data is well-matched by the steady-state values of the model. The "great ratios" - consumption and investment shares - are well-approximated, as well as the after-tax return to capital, where $\tilde{r} = (1-\tau^k)r-\delta$. Advertising and search costs are quite small relative to the size of the economy. Thus, despite the presence of search externalities the labor share is essentially identical to *wn/y*, which is the expression for the case of perfectly-competitive labor markets.

Table 2. Data Averages and Long-Run Solution

	Description	BG Data	Model
c/y	Consumption-to-output ratio	0.674	0.642
i/y	Fixed investment-to-output ratio	0.201	0.181
k/y	Physical capital-to-output ratio	13.96	13.96
g/y	Government consumption-to-output ratio	0.176	0.176
wn/y	Labor share in output	0.571	0.571
rk/y	Capital share in output	0.429	0.429
b_0s^η/y	Search cost-to-output per unemployed	N/A	0.001
av/y	Advertising vacancies cost-to-output	N/A	0.002
n	Employment rate	0.533	0.533

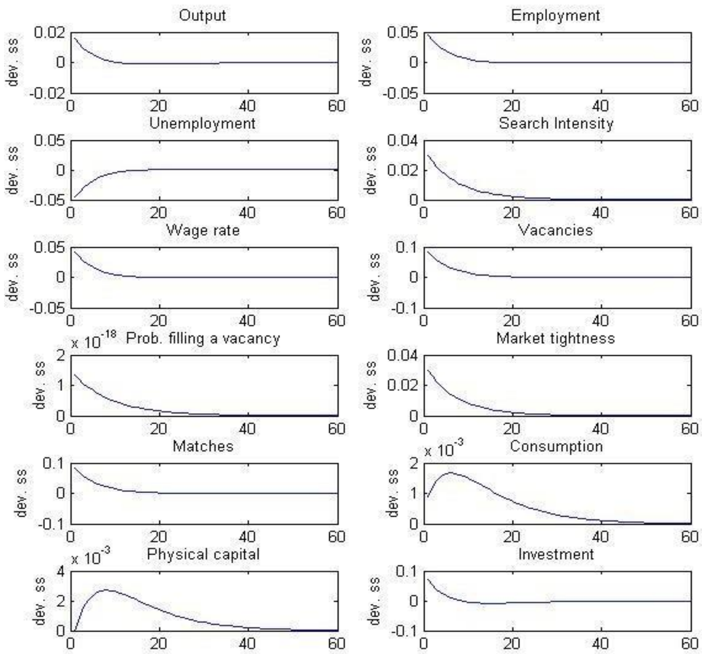
u	Unemployment rate	0.467	0.467
m	New matches	0.005	0.005
v	Vacancy rate	0.004	0.004
$\tilde{r}$	After-tax net return to physical capital	0.010	0.018

5. Out of Steady-State Model Dynamics

Since the model does not have an analytical solution for the equilibrium behavior of variables, we need to solve the model numerically, which is done by log-linearizing the original equilibrium (non-linear) system of equations around the steady state. This transforms the approximate dynamics of the model into one that is represented as 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 versus their empirical counterparts.

5.1 Impulse Response Dynamics

Figure 1. Impulse Responses to a 1% Technology Shock



This subsection documents the impulse responses of model variables to a 1% surprise innovation to technology. The impulse response function (IRFs) are in Fig. 2 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, and so consumption, investment, and government consumption also increase upon impact. At the same time, the increase in productivity raises the after-tax return on the two factors of production, labor and capital. Households respond to the incentives and start accumulating capital. In turn, the increase in capital input feeds back in output and adds to the effect of the technology shock.

In the labor market, which is characterized by trade frictions, households increase their search effort, as the value of being employed is now higher, which in turn increases the probability of a match. On the firm side, the increase in the marginal product of labor also makes the value of a filled vacancy higher, and so firms start advertising positions. Market tightness decreases, which lifts the probability of employment and decreases the congestion externalities in the labor market. The probability of becoming unemployed thus decreases. As a result, employment increases, and unemployment decreases. The number of matches being realized also increases. In turn, the increase in the labor input employed in the production further augments the increase in output.

As capital is being accumulated over time, its marginal product starts to decrease, which lowers the households' incentives to save. As a result, capital returns to its steady-state following its hump-shaped dynamics. Consumption also exhibits the same shape in its dynamic pattern. The other variables return to their old steady states in a monotone fashion.

5.2 Simulation and Moment-Matching

We now simulate the model 10,000 times for the length of the data horizon and detrend both empirical- and model-simulated data 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. To minimize the sample error, we average out the simulated moments over the computer-generated draws. The model-predicted standard errors are reported in brackets next to the mean estimate from the model. The model matches quite well the absolute volatility of output, and the empirical estimate is within the confidence band produced by the model. However, the model underestimates the variability in consumption, which could be due to the presence of government consumption, which overestimates the variability in data. The model also overestimates the variability in investment. This shortcoming of the model could be explained by the structural transformation of government property in private hands through voucher privatization, direct sales, and worker-management privatization. Public investment in infrastructure has been also substantial in the last few years. 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 the data.

With respect to the labor market variables, the variability of employment predicted by the model is about the same as the one in the data, but the variability of vacancies is not. The latter might be driven again by structural issues and structural transformation of the economy over the period. Nevertheless, the model is able to capture the Beveridge curve, the strong negative correlation between unemployment and vacancies documented in Fig. 1, despite the presence of a variable search effort, which, according to the Merz (1995) would cause the Beveridge curve to shift and generate zero correlation in the model. This negative co-movement between vacancies and unemployment is a stylized macroeconomic fact of the labor markets in other developed countries, *e.g.* the U.S., as documented in Krause and Lubik (2014), and lays at the heart of Shimer's (2005) puzzle, as the model fails to match the order of volatility of unemployment and vacancies. Moreover, the wage rate in the model is too volatile. As Merz (1995) points out, any incentives for firms to advertise a vacancy (due to increased productivity and thus a rise in the value of the filled vacancy) are quickly offset by the increase in wages. Thus, the model fails to reproduce the variability of both unemployment and vacancies. Vacancies vary more than in the data, and so tightness varies less than in the data. The reason behind this mismatch could be driven by several possible explanatory factors: (i) the fact that the model misses the out-of-labor force (discouraged workers) segment, which is significant in Bulgaria; (ii) the structural mismatch in the economy moving from agriculture and heavy manufacturing to services; and/or (iii) the significant emigration to Western Europe, the U.S. and Canada.

As in Andolfatto (1996) the wage rate behaves like average labor productivity. One reason for this is that the wage rule arising from Nash bargaining leads to Pareto optimal allocations. The other explanation is that the worker's outside option moves in the same direction as productivity in response to technology shocks. In addition, the volatility of wages is higher than the variability of labor productivity, which means that the labor share is pro-cyclical in Bulgaria. This is what we see from Table 3 above as well, which is typical for recession periods and a good description for Bulgaria's transitional experience. In a recession, capital absorbs most of the negative effect and falls more than proportionally, while labor falls less than proportionally. The latter is due to the presence of employment insurance, firing costs, and long-term contracts. Again, the standard RBC model does not explain this. In terms of contemporaneous correlations, the model slightly over-predicts the pro-cyclicality of the main macroeconomic variables - consumption, investment, and government consumption. However, this is a common limitation of the whole class of RBC models. Along the labor market dimension, the contemporaneous correlation of market tightness with output is well-matched. With the other variables, the signs are correct, but the model predicts a stronger co-movement than the one observed in the data. Overall, the model with search and matching provides a richer framework that is able to capture well more aspects of the Bulgaria labor market.

In the next subsection we take the analysis one step further. Instead of reporting only the contemporaneous correlation, we investigate the correlation between labor market variables at leads and lags, thus evaluating how well the model matches the phase dynamics among variables. In addition, we put the autocorrelation functions of empirical data, obtained from an unrestricted VAR(1), under scrutiny and compare and contrast them to their simulated counterparts generated from the model. Note that after log-linearization, the model could be viewed as a structural VAR model, with the only source of disturbance being the innovations to the total factor productivity.

Table 3. Business Cycle Moments

	Data	Model
σ_y	0.05	0.07 (0.01)
σ_c/σ_y	0.55	0.10 (0.02)

σ_i/σ_y	1.77	4.38 (0.02)
σ_g/σ_y	1.21	1.00 (0.00)
σ_n/σ_y	0.63	0.72 (0.02)
σ_{LS}/σ_y	0.43	0.31 (0.02)
σ_w/σ_y	0.83	2.38 (0.02)
$\sigma_{y/n}/\sigma_y$	0.86	1.72 (0.02)
σ_u/σ_y	3.22	0.86 (0.12)
σ_v/σ_y	2.54	4.52 (0.07)
σ_θ/σ_y	4.42	1.88 (0.04)
σ_w/σ_n	1.32	3.31 (0.02)
$corr(c, y)$	0.85	0.53 (0.06)
$corr(i, y)$	0.61	1.00 (0.00)
$corr(g, y)$	0.31	1.00 (0.00)
$corr(n, y)$	0.49	0.96 (0.01)
$corr(w, y)$	-0.01	-1.00 (0.00)
$corr(LS, y)$	0.48	0.42 (0.01)
$corr(\theta, y)$	-0.98	-0.95 (0.02)
$corr(u, y)$	-0.47	-0.95 (0.02)
$corr(v, y)$	0.49	0.99 (0.01)
$corr(n, y/n)$	-0.14	-0.97 (0.00)
$corr(u, v)$	-0.63	-0.98 (0.01)

5.3 Auto-Correlation and Cross-Correlation

This subsection discusses the auto-correlation functions (ACFs) and cross-correlation functions (CCFs) of the major model variables. We plot the empirical ACFs and CCFs (solid line) in Fig. 3 on the next page against the average simulated AFCs and CCFs, with the 95% confidence band (dashed line). The model compares the data quite well. Empirical ACFs for output and investment are slightly outside the confidence band predicted by the model, while the ACFs for total factor productivity, household consumption, and government consumption are well-approximated by the model. Labor market variables are also well-described by the model dynamics: ACFs for vacancies, employment, and unemployment are close to predicted ones until the third lag. The ACF for the wage rate is well-captured only until the first lag. However, this is a common shortcoming of this class of models; a wage rate determined within a Nash bargaining framework demonstrates such limitations (e.g. Shimer 2010). Overall, the search and matching model and the trade frictions in particular generate persistence in output and both employment and unemployment and are 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 model does not have a strong internal propagation mechanism besides the strong persistence in the TFP process. The search and matching approach also dominates the setup with indivisible hours (not shown here), developed by Rogerson (1988) and incorporated in the RBC setup by Hansen (1985). Those models setup the labor market in the Walrasian market-clearing spirit, and output and unemployment persistence is low. In contrast, the model with search and matching frictions is able to generate high persistence in lags, due to the history dependence arising from the employment status.

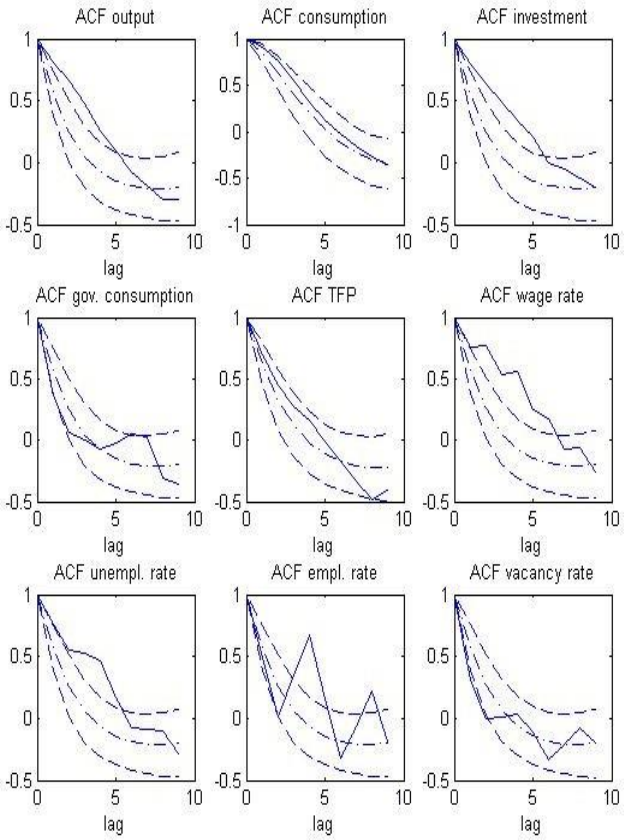


Table 4. Dynamic Correlations for Bulgarian Data and the Model Economy

		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	$corr(n_t, (y/n)_{t-k})$	0.000	0.000	0.000	0.002	0.000	0.000	0.000
	(s.e.)	(0.007)	(0.006)	(0.006)	(0.031)	(0.004)	(0.001)	(0.003)
Data	$corr(n_t, w_{t-k})$	0.335	0.452	0.447	0.328	-0.04	-0.39	-0.57
Model	$corr(n_t, w_{t-k})$	0.000	0.000	0.000	0.002	0.002	0.000	0.000
	(s.e.)	(0.002)	(0.006)	(0.002)	(0.044)	(0.005)	(0.001)	(0.003)
Data	$corr(v_t, u_{t-k})$	0.171	-0.314	-0.308	-0.630	-0.010	0.240	0.220

Model	$corr(v_t, u_{t-k})$	0.181	0.069	-0.166	-0.983	-0.042	0.182	0.257
	(s.e.)	(0.158)	(0.159)	(0.166)	(0.010)	(0.148)	(0.138)	(0.150)

The model approximates a very low contemporaneous correlation between wages and employment in Bulgaria quite well. Moreover, the wage rate is determined through a Nash-bargaining procedure; the presence of fiscal policy also helps to move the correlation in the right direction. Taxes decrease the return to both labor and capital, while the presence of government spending diverts some of the resources available, as non-productive ("wasteful") government consumption rule is modeled as a fixed share of output. Finally, the model also captures well the dynamic correlation between vacancies and unemployment in Bulgaria. An increase in vacancies leads to a decrease in unemployment, and that is what we see in the data. That is also a dimension that the standard RBC model calibrated for Bulgaria (Vasilev 2009) is unable to capture, since vacancies are not featured there.

5. Conclusions

In this paper we investigate the quantitative importance of search and matching frictions in the Bulgarian labor market, by augmenting an otherwise real business cycle model a la Long and Plosser (1983) with a two-sided costly search and fiscal policy. The model is consistent with the data along the labor market dimension, and dominated setups rooted in the perfectly-competitive labor markets paradigm, e.g. Vasilev (2009), as well as the indivisible labor extension used in Hansen (1985) The search-and-matching setup produces history-dependence in employment status, which raises the persistence in both employment and unemployment, something that Hansen's (1985) and Rogerson's (1988) setups are unable to capture, since running an unemployment lottery over time erases all history-dependence.

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