Optimal fiscal policy in a model with search-and-matching frictions: the case of Bulgaria (1999-2018)

Aleksandar Vasilev*

July 15, 2020

Abstract

This paper explores the effects of fiscal policy in an economy with search and matching frictions. To this end, a dynamic general-equilibrium model with government sector is calibrated to Bulgarian data (1999-2018). Two regimes are compared and contrasted - the exogenous (observed) vs. optimal policy (Ramsey) case. The focus of the paper is on the relative importance of consumption vs. income taxation, as well as on the provision of utility-enhancing public services. The main findings from the computational experiments performed in the paper are: (i) The optimal steady-state income tax rate is zero; (ii) The benevolent Ramsey planner provides the optimal amount of the utility-enhancing public services, which are now three times lower; (iii) The optimal steady-state consumption tax needed to finance the optimal level of government spending is 18.3%, slightly lower than the rate in the exogenous policy case.

JEL classification: D51, E24, E32, J40

Keywords: optimal (Ramsey) fiscal policy, general equilibrium, unemployment and wages, Bulgaria

*Lecturer, Lincoln International Business School, UK. E-mail for correspondence: AVasilev@lincoln.ac.uk.

1 Introduction

Since the early 1980s, many macroeconomic studies have focused on the effects of observed fiscal policy in general equilibrium setups, and in particular comparing and contrasting it to a benchmark, or "optimal fiscal policy" regime, e.g. Chari, Christiano and Kehoe (1994, 1999), for a survey. The setup was then used to inform policy-makers how to adjust the taxation and spending mix in order to minimize distortions, and thus improve the overall allocative efficiency in the economy. The main focus of those studies, mostly focused on the US, has been predominantly formulated as a problem of raising funds to finance a pre-determined level of government purchases through the use of distortionary taxes on the capital and labor inputs, and at the least possible cost. The literature focused on the choice between different types of income taxation, and abstracted away from taxes on final demand, such as the sales-, or value-added, taxation (VAT). This is understandable given the absence of a federal consumption tax in the US. However, the situation is quite different in Europe, where indirect taxes are very important instrument for raising tax revenue. Furthermore, there was also a recent move in Eastern Europe toward a common income tax rate, which was introduced in order to discourage individuals from income evasion by shifting income between labor and capital categories in order to minimize the overall tax burden.

Bulgaria, a small Eastern European economy, and a EU member-state as of 2007, adopted a public finance model that emphasized consumption-based taxation and a common income tax rate. As pointed in Vasilev (2018), VAT revenue is the major source of tax revenue in Bulgaria, responsible for almost half of the total tax revenue raised.[1] In addition, as of 2008 both capital and labor income, as well as corporate profits are taxed at the common rate of 10 %. Therefore, in addition to deciding on the optimal level of public spending, a fiscal authority in the Bulgarian (and also EU) context is choosing a different set of tax rates - a common income tax rate, and a tax rate on consumption.

[1]The other major source of revenue, making around a third of total tax revenues, are social contributions made by both employers and employees. Compared to consumption-based taxation, which is a tax on demand, income taxation in Bulgaria is of much smaller importance for the budget: for example, over the period 2007- 2014, taxation of both individuals and corporations constitutes around 10 % of overall tax revenue each

In addition, 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. Vasilev (2016) suggests that in order to capture adequately labor market dynamics in Bulgaria, one needs to abandon 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. This paper utilizes that search-and-matching framework and aims to model the labor market in Bulgaria after the introduction of the currency board (1997) in an equilibrium real business cycle model with fiscal policy.[2,3] The two-sided costly labor search and matching frictions introduced in the model setup create an inefficient outcome in the labor market due to the search and congestion externalities.[4] In the model utilized in this paper, search and recruiting activities are viewed as costly investment activities that help eventually augment the number of jobs created ("matches"), which in turn increases total employment. Similarly, the vacancies that are posted by employers could be viewed as an as asset that generates a value when the position is filled with a suitable candidate. The market tightness, defined as the ratio of vacancies-to-unemployment, causes the search and congestion externalities. With trade frictions in the market for labor, the search effort is suboptimal, thus the labor input is rationed. Since this rationing is stochastic (due to the

[2]For empirical studies on labor markets in Bulgaria the interested reader is referred to Lozev *et al.* (2011), Paskaleva (2016), and the references therein.

[3]Earlier periods are excluded due to the low-quality of data from the early 1990s and the volatile time period of the financial crisis from 1996-97.

[4]This rigidity could be driven by heterogeneity of workers' skill level, or the time cost involved due to the imperfect information possessed by either side of the market. Kennan (2006) emphasizes the importance of private information to explain unemployment over the business cycle. Vasilev (2017a, 2017b) present some results using setups where workers' effort is unobservable. For an excellent treatment on how earlier search literature merged with the RBC literature, the interested reader is referred to Ramey (2011). In addition, as Shimer (2010) argues, the search and matching mechanism could be regarded as the process captured by the ad hoc convex labor adjustment costs introduced in some macroeconomic models, *e.g.* Hansen and Sargent (1988), which helped the framework amplify employment fluctuations.

limited information about candidates on the market and available positions), the price, *i.e.*, the wage rate, is not the only allocative mechanism. Therefore, the inefficiency cannot be eliminated by wage adjustments alone.

On the worker side, working is generally more valuable than being unemployment. However, under certain conditions, unemployment may be 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 employment in equilibrium. More specifically, in each period matches are destroyed with some exogenous probability, and any employed person faces a risk of being laid off.[5] The process of trading the labor input in an environment featuring imperfect information, or equivalently, the search and matching frictions present in the labor markets provide a tractable mechanism which is both realistic and plausible.

We then proceed to characterize optimal (Ramsey) fiscal policy in the context of search and matching frictions in the labor market and then to evaluate it relative to the exogenous (observed) fiscal policy regime. The novelty is that the public finance problem with search and matching frictions is thus different from the standard one described in Chari, Christiano and Kehoe (1994, 1999). Similar to earlier literature, e.g. Judd (1985), Chamley (1986), and Zhu (1992), allowing distortionary taxation in a dynamic general-equilibrium framework creates interesting trade-offs: On the one hand, valuable government services directly increase household's utility. On the other, the proportional income taxes will negatively affect the incentives to supply labor and to accumulate physical capital. The presence of search and matching frictions creates interesting interactions, and they introduce history dependence in the employment status, and unemployment will respond to the after-tax wage. In turn, higher taxes reduce not only income, but also consumption, which is actually hit twice due to a second round of taxation, this time at the point of consumption. Both types of taxes lower welfare, both directly, and indirectly, by generating less tax revenue which could be

[5] The assumption of an exogenous job destruction rate is mainly for analytical convenience and model tractability. Endogeneizing the separation rate, as pointed out in Pissarides (2000), does not alter fundamentally the job creation and job search processes. Den Haan *et al.* (2000) show that this feature adds more persistence to the model variables and helps the setup capture better the volatility in job creation and job destruction.

spent on valuable public services. The optimal fiscal policy problem discussed in this paper is to choose consumption and a common income tax rate to finance both utility-enhancing and redistributive government expenditure, while at the same time minimizing both the allocative distortions created in the economy, as a result of the presence of proportional taxation. The main findings from the computational experiments performed in the paper are: (i) The optimal steady-state income tax rate is zero; (ii) The benevolent Ramsey planner provides the optimal amount of the utility-enhancing public services, which are now three times lower; (iii) The optimal steady-state consumption tax needed to finance the optimal level of government spending is 18.7%, slightly lower than the rate in the exogenous policy case.

The rest of the paper is organized as follows: Section 2 describes the model framework and the decentralized equilibrium system, Section 4 discusses the calibration procedure, and Section 4 presents the steady-state model solution. Sections 5 proceeds with the optimal taxation (Ramsey) policy problem, and evaluates the long-run effects on the economy. Section 6 concludes the chapter.

2 Model Setup

The structure of the model economy follows closely Vasilev (2016): There is a unit mass of households, as well as a representative firm. The households own the 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 utility-enhancing government consumption and the lump-sum government transfers.

2.1 Households

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

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

where E_0 denotes the expectations operator as of time 0, C_t, N_t denote consumption, hours (employment),[6] and government services in period t, respectively; $0 < \beta < 1$ is the discount factor, and $\phi, \mu > 0$ denotes the relative weight attached to leisure and public goods in the households' utility, respectively. As in Andolfatto (1996), households will be pooling together all resources and in this way achieve full insurance against the contingency of unemployment. As a result, consumption will be identical across households regardless of the employment status.

The households own all the capital in the economy. Aggregate physical capital evolves according to the following law of motion:

$$K_{t+1} = I_t + (1 - \delta)K_t, \tag{2}$$

where $0 < \delta < 1$ is the depreciation rate. Households will rent the capital to the firm at the rate r_t, generating $r_t K_t$ in before-tax capital income.

Another source of income for the households is the labor income. Aggregate employment evolves according to

$$N_{t+1} = (1 - \psi)N_t + p_t S_t(1 - N_t), \tag{3}$$

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 the tightness of the labor market. Households take the probability p_t at which the aggregate search effort produces a match as given. Aggregate before-tax labor income is then $w_t N_t$, where w_t is the hourly wage rate in the economy.

[6] This equivalence follows from the normalization of the mass of households, as well as setting total time endowment equal to unity.

Households can decide to use time and effort to improve their chances of forming a match. As in Vasilev (2016), the search cost function is assumed to be monotone in the search intensity and of the form

$$b_0 S_t^{\eta}(1 - N_t), \tag{4}$$

where $b_0 > 0$, $\eta \geq 1$, and $S_t > 0$.[7] That is, the cost of searching for a job is $b_0 S_t^{\eta}$ per household, and the mass of unemployed households is $1 - N_t$. Since search cost produces a waste of resources in the economy, total search cost will be accounted for as an output cost.[8] Households own the firm in the economy and claim all the profit. Households' budget constraint is then

$$(1 + \tau^c)C_t + K_{t+1} - (1 - \delta)K_t + b_0 S_t^{\eta}(1 - N_t) \leq (1 - \tau^y)[r_t K_t + w_t N_t + \Pi_t] + G_t^{tr}, \tag{5}$$

where $\{\tau^c, \tau^y\}$ is the consumption and income tax rate, Π_t denote firm's aggregate profits, and G_t^{tr} are government transfers.

Taking the tax rates $\{\tau^c, \tau^y\}$, prices $\{w_t, r_t\}_{t=0}^{\infty}$, profit $\{\Pi_t\}_{t=0}^{\infty}$, government transfers $\{G_t^{tr}\}_{t=0}^{\infty}$, 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 (1) s.t. (2)-(5). The resulting first-order optimality conditions (FOCs), and the transversality condition (TVC) are as follows:

$$C_t \quad : \quad \frac{1}{C_t} = \lambda_t(1 + \tau^c) \tag{6}$$

$$K_{t+1} \quad : \quad \lambda_t = \beta E_t \lambda_{t+1}[(1 - \tau^y)\alpha \frac{Y_{t+1}}{K_{t+1}} + (1 - \delta)] \tag{7}$$

$$S_t \quad : \quad \lambda_t b_0 \eta S_t^{\eta-1} = \mu_t p_t \tag{8}$$

$$N_{t+1} \quad : \quad \frac{b_0 \eta S_t^{\eta-1}}{C_t} = p_t \beta E_t \Bigg\{ \frac{1}{C_{t+1}} \Bigg[(1 - \tau^y) w_{t+1} + b_0 S_{t+1}^{\eta} \Bigg] + \frac{\phi}{1 - N_{t+1}} + \frac{b_0 \eta S_{t+1}^{\eta-1}}{C_{t+1} p_{t+1}} [(1 - \psi) - p_{t+1} S_{t+1}] \Bigg\} \tag{9}$$

$$(TVC) \quad : \quad \lim_{t \to \infty} \frac{1}{C_t} K_{t+1} = 0 \tag{10}$$

[7] Similarly, Seater (1979) also argues that the search cost function should be increasing at the margin.

[8] Other authors that take this approach, are Phelps *et al.* (1970), Pissarides (1988), and Pissarides (1990).

where λ_t, 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, corrected for the consumption tax rate. The second is the so-called Euler condition, which describes how households would 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 one periods. 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 Vasilev (2016), this benefit is conditioned on "any additional search effort leading to a job match with probability p_t." The TVC is a boundary condition on capital, which guarantees that explosive solutions are ruled out.

2.2 Firm

There is a representative firm in the setup using a Cobb-Douglas production function,[9] which uses both capital and labor

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}, \tag{11}$$

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. Firm's 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.

[9]The assumption of constant returns to scale is a useful one, as it allows to think of the stand-in form as an aggregation of single-vacancy outlets.

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

$$N_{t+1} = (1-\psi)N_t + q_t V_t \tag{12}$$

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

FOCs:

$$K_t \ : \ \alpha\frac{Y_t}{K_t} = r_t \tag{13}$$

$$N_t \ : \ \beta_t\left[(1-\alpha)\frac{Y_{t+1}}{N_{t+1}} - w_{t+1} + \frac{a(1-\psi)}{q_{t+1}}\right] = \frac{a}{q_t} \tag{14}$$

The first one is the usual optimality condition for capital, saying that the input is rewarded its marginal product. The optimality condition for labor is different from the one in standard RBC models. In the literature, the second optimality condition is also referred to as the job creation condition (JCC).[10] 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 destroyed.

2.3 Matching technology

Aggregate job matches are assumed to be generated by the following production function:

$$M_t = V_t^{1-\gamma}[S_t(1-N_t)]^{\gamma}, \tag{15}$$

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)

[10]Vacancies are already chosen optimally, and the optimality condition was plugged in the JCC equation.

and Hosios (1990) also argue that search effort should be also included as in input in the aggregate matching function, hence the specification used above.

In addition, this type of modeling matches as described above implies endogenous probabilities for the transition from unemployment to employment, defined as

$$p_t = \frac{M_t}{S_t(1-N_t)} = \left(\frac{\theta_t}{S_t}\right)^{1-\gamma}, \tag{16}$$

where

$$\theta_t = \frac{V_t}{1-N_t} = \frac{V_t}{U_t} \tag{17}$$

represents the tightness of the labor 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 θ, or

$$p(\theta_t) = \frac{M_t}{1-N_t} = \left(\frac{\theta_t}{S_t}\right)^{1-\gamma}. \tag{18}$$

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,

$$q_t = \frac{M_t}{V_t} = \left(\frac{S_t}{\theta_t}\right)^{\gamma} \tag{19}$$

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

$$q(\theta_t) = \left(\frac{S_t}{\theta_t}\right)^{\gamma}. \tag{20}$$

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

$$\frac{1}{q_t} = \frac{1}{q(\theta_t)}, \tag{21}$$

can be interpreted as the expected duration of a vacancy.

2.4 Wage determination

The wage rate will be determined as an outcome from a Nash bargaining protocol, where the worker and the firm will negotiate over the distribution of the rents arising from the value of the match. In technical terms,

$$w_t = \arg\max_{w} [W_t - U_t]^{\lambda} [J_t - Q_t]^{1-\lambda}, \tag{22}$$

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 perspective, the surplus from the match is the difference between the value J_t from filling a vacancy and Q_t is the value from an unfilled vacancy. It is a standard result (Shimer 2010) that the wage rate obtained is[11]

$$w_t = \lambda \left[(1-\alpha)\frac{Y_t}{N_t} + a\frac{V_t}{1-N_t} \right] + (1-\lambda)\left[-\frac{\phi C_t}{1-N_t} - b_0 S_t^{\eta} \right] \tag{23}$$

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

$$w_t = \gamma \left[(1-\alpha)\frac{Y_t}{N_t} + a\frac{V_t}{1-N_t} \right] + (1-\gamma)\left[-\frac{\phi C_t}{1-N_t} - b_0 S_t^{\eta} \right] \tag{24}$$

The expression above is also referred to as a wage schedule, or a "wage curve," as documented in Blanchflower and Oswald (1994).

A job is an asset owned by the firm, 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 the 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 firm's expected profit from a vacant job. The wage rate is then the weighted average of the marginal product of labor and the marginal rate of substitution between consumption and hours, where the latter can be

[11] For detailed derivations, the interested reader is referred to Vasilev (2016).

regarded as the 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. We can think of the wage expression as representing the two "threat points" in the wage negotiations: on the one hand, the household asks for the value of its marginal product less the cost of advertising born by the firm. The firm, however, would be only 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, with 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 Stochastic process

It will be assumed that total factor productivity (TFP) process $\{A_t\}_{t=0}^{\infty}$ is stochastic, and follows an AR(1) dynamics

$$A_{t+1} = (1 - \rho_a)A_0 + \rho A_t + \epsilon_{t+1}^a, \tag{25}$$

where $A_0 = A$ is the steady-state level of TFP, parameter ρ_a measures the persistence of the process, and $\epsilon_t \sim N(0, \sigma_a^2)$ are the unexpected innovations to the TFP, which are i.i.d. normal with zero mean and standard deviation σ_a.

2.6 Government

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

$$\tau^c C_t + \tau^y [r_t K_t + w_t N_t] = G_t^c + G_t^{tr}, \tag{26}$$

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

2.7 Decentralized Competitive Equilibrium (DCE) with Search Externalities

Given the total factor productivity (TFP) process $\{A_t\}_{t=0}^{\infty}$, the two tax rates $\{\tau^c, \tau^y\}$, the initial conditions for the (endogenous and exogenous) state variables k_0, A_0, a Decentralized Competitive Equilibrium (DCE) with search is defined to be a sequence of prices $\{r_t, w_t\}_{t=0}^{\infty}$, allocations $\{c_t, i_t, k_t, s_t, n_t, u_t, g_t^c, g_t^{tr}\}_{t=0}^{\infty}$, 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; (iv) all markets clear.

3 Data and model calibration

The model is calibrated to Bulgarian data at quarterly frequency. The period under investigation is 2000-2018. Quarterly data on the output, household and government consumption, private fixed investment shares in output, employment rate, the unemployment rate, and the vacancy rate was obtained from the National Statistical Institute (2019). Following Vasilev (2015), capital income share is set to its average value $\alpha = 0.429$, and the labor income share is $1 - \alpha = 0.571$. Next, using Vasilev's (2015) estimate that the annual depreciation rate on physical capital is 5 %, in our quarterly model that 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 that $K/Y = 13.964$. This gives us sufficient information to calibrate the discount factor from the steady-state Euler equation:

$$\beta = \frac{1}{1 + \alpha \frac{y}{k} - \delta} = 0.982.$$

The relative weight on leisure in the household's utility function, parameter $\phi = 1.803$, will be set to match the steady-state employment rate in Bulgaria over the period, $n = 0.533$. The weight attached to public goods will be set to reflect the observed ratio of private-to-public consumption. Steady-state output will be normalized to unity, which produces $A = 0.605$. Burda (1997) estimates $m/n = 0.009$ for Bulgaria, which yields $\psi = 0.009$. The two tax rates are set to their rates in data.

Scale parameter of the search cost function $b_0 = 0.001$, which is of the magnitude chosen in Vasilev (2016). Similarly, due to lack of information, we will assume linear search costs and set $\eta = 1$. Again, the curvature of the search cost function does not affect our results quantitatively. Following Vasilev (2016), for the advertising costs, we set per vacancy cost $a = 0.1$. Since the shares of the search and recruiting costs in output will be shown in the next section to be minute, 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, usually is estimated from matching function. However, given the short series available for Bulgaria, $\lambda = \gamma = 0.4$ will be adopted from Blanchard and Diamond (1990) and Petrolongo and Pissarides (2001).

Finally, the parameters for the total factor productivity process will be estimated by obtaining the Solow residuals from the Cobb-Douglas production function using data on output, capital and employment, and the estimated capital share. The Solow residuals are then detrended, and an AR(1) model is estimated using Ordinary Least Squares (OLS). That produced the consistent estimates $\hat{\rho}_a = 0.7$ with $s.e.(\hat{\rho}_a) = 0.117$, and $\hat{\sigma}_a = 0.044$, which will be used in the simulation stage. Table 1 below summarizes the values of model parameters used in this paper.

4 Steady-State

Once model parameters were obtained, the steady-state ratios for the model calibrated to Bulgarian data were obtained. The results are reported in Table 2 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 $\tilde{r} = (1 - \tau^y)r - \delta$. 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 in the case with perfectly-competitive labor markets.

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
μ	0.250	Weight attached to utility of public goods	Calibrated
η	1.000	Curvature of the search cost function	Calibrated
γ	0.400	Elasticity of job matches with respect to search effort	Calibrated
$1-\gamma$	0.600	Elasticity of job matches with respect to vacancies	Calibrated
ψ	0.009	Transition rate from employment to unemployment	Data Avg.
a	0.100	Per-unit advertising costs	Set
b_0	0.001	scale parameter, search cost function	Set
τ^c	0.200	Consumption tax rate	Data Avg.
τ^y	0.100	Income tax rate	Data Avg.
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

5 The Ramsey problem (Optimal fiscal policy under full commitment)

In this section, we solve for the optimal fiscal policy scenario under full commitment. More specifically, the government will be modelled as a benevolent planner, who has the same preferences as the people in the economy, *i.e.*, it will choose to maximize the household's utility function, while at the same time taking into account the optimality conditions by both the household and the firm, or the equations describing the DCE.[12] The fiscal instruments at government's disposal are consumption and income tax rate, and the level of public

[12]Note that when the household and the firm are making optimal choices, they are taking all fiscal policy variables as given. Also note that the benevolent government treats everyone the same.

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 cons-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
$b_0 s^\eta/y$	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

consumption spending.[13] In addition, it will be assumed that the government can also fully and credibly commit to the future sequence of taxes and spending until the end of the optimization period, so the policy is time-consistent. Under the Ramsey framework, the choice variables for the government are $\{c_t, n_t, s_t, g_t^c, k_{t+1}, w_t, r_t\}_{t=0}^{\infty}$ plus the two tax rates $\{\tau_t^c, \tau_t^y\}_{t=0}^{\infty}$. The initial conditions for the state variable k_0, as well as the realized sequence of government transfers $\{g_t^t\}_{t=0}^{\infty}$ and the fixed level of total factor productivity A are taken as given. The optimal policy problem is then recast as a setup where the government chooses after-tax input prices $\tilde{w}_t$ and $\tilde{r}_t$ directly, where

$$\tilde{w}_t = (1-\tau_t^y)w_t \tag{27}$$

$$\tilde{r}_t = (1-\tau_t^y)r_t. \tag{28}$$

Thus, government budget constraint is now represented by

$$\tau_t c_t + A k_t^\alpha n_t^{1-\alpha} - \tilde{r}_t k_t - \tilde{w}_t h_t = g_t^c + g_t^t \tag{29}$$

[13]Note that the government transfers will be held fixed at the level computed from the equilibrium under the exogenous policy case.

The Ramsey problem then simplifies to and becomes

$$\max_{\{c_t,n_t,g_t^c,k_{t+1},\tilde{r}_t,\tau_t^c\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \bigg\{ \ln c_t + \phi \ln(1-n_t) + \mu \ln g_t^c \bigg\}. \tag{30}$$

s.t.

$$\frac{1}{c_t} = \beta \frac{1}{c_{t+1}} [1 + \tilde{r}_{t+1} - \delta] \tag{31}$$

$$Ak_t^{\alpha} n_t^{1-\alpha} = c_t + k_{t+1} - (1-\delta)k_t + b_0 s_t^{\eta}(1-n_t) + g_t^c \tag{32}$$

$$\tau_t c_t + Ak_t^{\alpha} n_t^{1-\alpha} - \tilde{r}_t k_t - \tilde{w}_t n_t h = g_t^c + g_t^t \tag{33}$$

$$n_{t+1} = (1-\psi)n_t + p_t s_t (1-n_t) \tag{34}$$

In order to solve the problem we set up the corresponding Lagrangian (use μ-s for Lagrangian multipliers).

$$\begin{aligned} \mathcal{L} = \max_{\{c_t,n_t,g_t^c,k_{t+1},\tilde{r}_t,\tau_t^c\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \bigg\{ \ln c_t + \phi \ln(1-n_t) + \mu \ln g_t^c \bigg\}, \\ + \beta^t \mu_t^1 \bigg[- c_{t+1} + \beta c_t (1 + \tilde{r}_{t+1} - \delta) \bigg] \\ + \beta^t \mu_t^2 [Ak_t^{\alpha} n_t^{1-\alpha} - c_t - k_{t+1} + (1-\delta)k_t - g_t^c] \\ + \beta^t \mu_t^3 [\tau_t c_t + Ak_t^{\alpha} n_t^{1-\alpha} - \tilde{r}_t k_t - \tilde{w}_t n_t h - g_t^c - g_t^t] \\ + \beta^t \mu_t^4 [-n_{t+1} + (1-\psi)n_t + p_t s_t (1-n_t)] \end{aligned} \tag{35}$$

The first-order conditions are as follows:

$$c_{t+1} \quad : \quad \frac{\beta}{c_{t+1}} - \mu_t^1 + \beta^2 \mu_{t+1}^1 (1 + \tilde{r}_{t+2} - \delta) - \beta \mu_{t+1}^2 + \beta \mu_{t+1}^3 \tau_{t+1}^c = 0 \tag{36}$$

$$k_{t+1} \quad : \quad \mu_t^2 = \beta \mu_{t+1}^2 [\alpha A k_t^{\alpha-1} n_t^{1-\alpha} + 1 - \delta] + \beta \mu_{t+1}^3 [\alpha A k_t^{\alpha-1} n_t^{1-\alpha} - \tilde{r}] \tag{37}$$

$$\begin{aligned} n_t \quad : \quad & \beta \frac{b_0 \eta s_{t+1}^{\eta}}{c_t} + \frac{\beta \phi}{1 - n_{t+1}} = \beta \mu_{t+1}^2 (1-\alpha) \frac{y_{t+1}}{n_{t+1}} + \mu_{t+1}^3 [(1-\alpha) \frac{y_{t+1}}{n_{t-1}} - \tilde{w}_{t+1}] \\ & - \mu_t^4 + \beta \mu_{t+1}^4 [(1-\psi) - p_t s_t] \end{aligned} \tag{38}$$

$$s_t \quad : \quad \frac{1}{c_t} (1 + \tau^c) b_0 \eta s_t^{\eta-1} = \mu_t^4 p_t \tag{39}$$

$$g_t^c \quad : \quad \frac{\gamma}{g_t^c} = \mu_t^2 + \mu_t^3 \tag{40}$$

$$\tilde{r}_t \quad : \quad \beta c_t \mu_t^1 = \beta \mu_{t+1}^3 k_t \tag{41}$$

We can also add the equations for the auxiliary variables, namely

$$y_t = Ak_t^{\alpha} n_t^{1-\alpha} \tag{42}$$

$$y_t = c_t + k_{t+1} - (1-\delta)k_t + b_0 s_t^{\eta}(1-n_t) + av_t + g_t^c \tag{43}$$

$$i_t = k_{t+1} - (1-\delta)k_t \tag{44}$$

$$r_t = (1-\alpha)\frac{y_t}{k_t} \tag{45}$$

$$w_t = \gamma\left[(1-\alpha)\frac{y_t}{n_t} + a\frac{v_t}{1-n_t}\right] + (1-\gamma)\left[-\frac{\phi c_t}{1-n_t} - b_0 s_t^{\eta}\right] \tag{46}$$

As in Vasilev (2018d), we have shut down all stochasticity (uncertainty) and focus on the steady-state allocations and prices. We solve the problem numerically and report the results in Table 3 below against the values from the exogenous (observed) policy case.

As expected, total discounted welfare is higher under the Ramsey regime: parameter ξ,

Table 3: Data Averages and Long-run Solution

Variable	Description	Data	Model (exo policy)	Model (optimal)
y	Steady-state output	N/A	1.000	1.061
c/y	Consumption-to-output ratio	0.674	0.642	0.724
i/y	Fixed investment-to-output ratio	0.201	0.181	0.224
k/y	Physical capital-to-output ratio	13.96	13.96	17.90
g/y	Government cons-to-output ratio	0.176	0.176	0.052
wn/y	Labor share in output	0.571	0.571	0.571
rk/y	Capital share in output	0.429	0.429	0.429
n	Employment rate	0.533	0.533	0.586
u	Unemployment rate	0.467	0.467	0.414
m	New matches	0.005	0.005	0.0053
v	Vacancy rate	0.004	0.004	0.0043
τ^y	Income tax rate	0.100	0.100	0.000
τ^c	Consumption tax rate	0.200	0.200	0.183
ξ	Welfare gain (% cons.)	-	0.000	0.603

documents a substantial welfare gain in terms of higher steady-state consumption (60%), which can be achieved when the economy moves to the optimal fiscal policy case. Next, private consumption, private capital- and investment are higher under the optimal policy regime, and thus the interest rate is lower. The model generates a zero long-run income tax, which consistent with the findings in earlier studies, *e.g.* Judd (1985), Chamley (1986), and Zhu (1992). This leads to higher capital input and employment in steady-state, which in turn translates into higher output and investment. Under Ramsey, public consumption is three times lower; to finance the decreased government spending on public goods, consumption tax rate can be lowered to 18.3 %. Therefore, the optimal policy suggests abolishing all direct taxation, and adopt a public finance model that relies exclusively on indirect taxation, as well as a much smaller size of the government. These results are new and could be of interest to policy makers.

6 Conclusions

This paper explores the effects of fiscal policy in an economy with search and matching frictions in the labor market, consumption taxes, and a common income tax rate in place. To this end, a dynamic general-equilibrium model with government sector is calibrated to Bulgarian data (1999-2018). Two regimes are compared and contrasted - the exogenous (observed) vs. optimal policy (Ramsey) case. The focus of the paper is on the relative importance of consumption vs. income taxation, as well as on the provision of utility-enhancing public services. Bulgarian economy was chosen as a case study due to its major dependence on consumption taxation as a source of tax revenue. The main findings from the computational experiments performed in the paper are: (i) The optimal steady-state income tax rate is zero; (ii) The benevolent Ramsey planner provides the optimal amount of the utility-enhancing public services, which are now three times lower; (iii) The optimal steady-state consumption tax needed to finance the optimal level of government spending is 18.7%, slightly lower than the rate in the exogenous policy case.

Ethical Statement: The Author declares that he has no conflict of interest. This article does not contain any studies with human participants or animals performed by any of the authors.

References

Andolfatto, D. (1996) "Business cycles and labor market search," *American Economic Review* 86(1): 112-132.

Blanchard, O.J. and P. Diamond (1989) "The Beveridge Curve," Brookings Papers on Economic Activity, 1-60.

Blanchard, O.J. and P. Diamond (1990) "The aggregate matching function," 159-201, in Peter Diamond, ed., *Productivity/growth, unemployment*. MIT Press, Cambridge: Mass.

Blanchflower, D. G. and A. J. Oswald (1994) *The Wage Curve*. MIT Press: Cambridge, UK.

Burda, M. (1997). "Unemployment, labor markets and structural change in Eastern Europe," in: *Transition to the market Economy: Critical Perspectives on the World Economy*, by Paul hare and Junior R. Davis(eds.), Routledge: Taylor and Francis, US.

Chamley C (1986): "Optimal Taxation of Capital Income in General Equilibrium." *Econometrica* 54:604-622.

Chari V.V, Kehoe P (1994): "Optimal Fiscal Policy in a Real Business Cycle Model." *Journal of Political Economy* 102(4):617-652.

Chari V.V., Kehoe P (1999): "Optimal Fiscal and Monetary Policy." In: Taylor J, Woodford M (eds): *Handbook of Macroeconomics*, vol.1(Amsterdam: North-Holland).

Den Haan, W. G. Ramey and J. Watson (2000) "Job Destruction and the Propagation of Shocks," *American Economic Review*, 90: 482-498.

Diamond, P.A (1982) "Wage determination and Efficiency in Search Equilibrium," *Review of Economic Studies*, 49: 217-227.

Hansen, G. D. and Sargent, T. J. (1988) "Straight time and overtime in equilibrium," *Journal of Monetary Economics*, 21(2-3): 281-308.

Hosios, A.J. (1990) "On the efficiency of matching and related models of search and unemployment," *Review of Economic Studies* 57, 279-298.

Judd K (1985): "Redistributive Taxation in a Simple Perfect Foresight Model." *Journal of Public Economics*, 28:59-83.

Kennan, J. (2006) "Private Information,Wage Bargaining and Employment Fluctuations," *NBER Working Paper* 11967.

Lozev, I., Vladova, Z., and Paskaleva, D. (2011) "Wage-setting behavior of Bulgarian firms: Evidence from survey data," *Discussion Paper* 87, Bulgarian National Bank, Sofia, Bulgaria.

Mortensen, D. T. (1982) "The matching process as a non-cooperative/bargaining game." In: *Economics of Information and Uncertainty*, by J.J. McCall (ed.). University of Chicago Press: Chicago, IL.

National Statistical Institute (2019) *NSI Statistical Database*. Available on-line at www.nsi.bg. Last accessed on November 14, 2019.

Paskaleva, D. (2016) "Labour cost and price adjustment practices of Bulgarian firms in the period 2009-13," *Discussion Paper* 101, Bulgarian National Bank, Sofia, Bulgaria.

Petrongolo, B. and C.A. Pissarides (2001) "Looking into the black box: A survey of the matching function," *Journal of Economic Literature*, 39: 390-431.

Phelps, E.S.(1970) *Microeconomic foundations of employment and inflation theory* (ed). Norton: New York, NY.

Pissarides, C.A. (1985) "Short-Run Equilibrium Dynamics of Unemployment, Vacancies, and Real Wages," *American Economic Review*, 75(4): 676-90.

Pissarides, C.A. (1986) "Unemployment and vacancies in Britain," *Economic Policy* 3, 499-559.

Pissarides, C.A. (2000) *Equilibrium Unemployment Theory*, 2nd ed. The MIT Press: Cambridge, Mass.

Ramey, V.A. (2011) "A Brief History of the Real Business Cycle-Search & Matching Literature," Mimeo.

Seater, J.J. (1977) "A unified model of consumption, labor supply and job search," *Journal of Economic Theory* 14: 349-72.

Shimer, R. (2005) "The Cyclical Behavior of Equilibrium Unemployment and Vacancies," *American Economic Review* 95: 25-49.

Shimer, R. (2010) *Labor Markets and Business Cycles*, Princeton University Press: Princeton, US.

Vasilev, A. (2018) "Optimal Fiscal Policy in the Presence of VAT Evasion: The Case of Bulgaria," *Czech Journal of Economics and Finance* 68(4): 399-414.

Vasilev, A. Z. (2017a) "A Real-Business-Cycle model with efficiency wages and a government sector: the case of Bulgaria," *Central European Journal of Economics and Econometrics*, Vol. 9, Issue 4, pp. 359-377.

Vasilev, A. Z. (2017b) "A Real-Business-Cycle model with reciprocity in labor relations and fiscal policy: the case of Bulgaria," *Bulgarian Economic Papers* BEP 03-2017, Center for Economic Theories and Policies, Sofia University St. Kliment Ohridski, Faculty of Economics and Business Administration, Sofia, Bulgaria.

Vasilev, A.Z. (2016) "Search and matching frictions and business cycle fluctuations in Bulgaria," *Bulgarian Economic Papers* 03-2016, Center for Economic Theories and Policies, Sofia University St. Kliment Ohridski, Sofia, Bulgaria.

Vasilev, A.Z. (2009) "Business cycles in Bulgaria and the Baltic countries: an RBC approach," *International Journal of Computational Economics and Econometrics*, vol. 1(2), pages 148-170.

Zhu X (1992): "Optimal Fiscal Policy in a Stochastic Growth Model." *Journal of Monetary Economics*, 58:250-289.