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Optimal Fiscal Policy in an Open Economy with Capital Income Shifting and Consumer Cross-border Purchases**

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Abstract: *The paper presents a fiscal policy model integrating tax avoidance, the complexity of tax systems and the fiscal solvency hypothesis within the traditional framework of tax competition. Furthermore, we take into account: taxation of consumption, possibility of capital income shifting and foreign goods purchases (untaxed in the destination country). We conclude that if fiscal policy is by no means unfettered, the equilibrium can be allocation efficient, provided that the marginal rate of substitution between private and public goods is one. The changes in public debt affect tax rates in equilibrium differently: positively for the consumption tax rate and negatively for the labor tax rate. The change of the capital tax depends on the level of economic internalization. This approach is especially use-*

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ful during a solvency crisis and can be applied to predict tax rates' adjustment when the bonds issuance decreases or public debt accelerates.

Introduction

In order to increase production and employment and, consequently, household income, a government may set tax rates that attract production factors. In this way, it influences international movement of production factors, particularly capital. In response, foreign countries can do the same. International tax competition is encountered when a government creates more favorable conditions of business taxation than those abroad in order to boost national economy. Economists differently assess the effects of tax competition. According to some, this will – assuming free international movement of capital and people – lead to alignment of relations in competing economies between what a taxpayer pays and what he receives in return. In this sense, as derived from Tiebout (1956, pp. 416-424), fiscal competition is beneficial because it helps to improve social welfare. According to others (Zodrow & Mieszkowski, 1986, pp. 356-370), tax competition is harmful because it leads to excessive reduction in supply of public goods. Zodrow and Mieszkowski model has a number of simplifying assumptions, namely:

- production capabilities of the economies involved in tax competition are symmetric;
- each economy produces one private and one public good;
- the markets are perfectly competitive;
- consumer preferences are homogeneous and distribution of income is uniform;
- the only variable and mobile factor of production is capital, and its rate of return is fixed;
- government seeks to maximize social welfare measured by the total utility of all consumers (Kudła, 2013).

Although the basic model assumptions were modified by introducing, e.g.: heterogeneous economies (Wildasin, 1988, pp. 229-240; Bucovetsky, 1991, pp. 333-350; Wilson, 1991, pp. 423-451), tax-mix policy (Bucovetsky & Wilson, 1991, 333-350; Gordon & Wilson, 2001; Gordon & Hines, 2002), or maximization of tax revenues as the government's objective (Edwards & Keen, 1996, pp. 113-134), the general conclusion about the harmful effects of tax competition and the consequent need for the harmonization of tax policy has not been undermined. Empirical studies have not given a clear-cut answer, confirming (Winner, 2005, pp. 667-687; Bé-

nassy-Quéré *et al.*, 2007, pp. 385-430) or denying the theoretical proposition (Garrett & Mitchell, 2001; Swank, 1998). Moreover, as observed in recent decades, the share of revenues from taxation of capital in total budget revenues and GDP of the EU countries, in general, has increased rather than declined (Devereux *et al.*, 2002, pp. 451-495), which is contrary to the proposition of the theory of harmful tax competition. Further development of the basic model has led to the formulation of a number of alternative hypotheses answering the challenges of empirical research, i.e.:

- easing fiscal instability as a result of opening economies and globalization of business activity with an increase of public spending and consequently – in order to cover them – an increase in taxes (Swank, 1998, pp. 671-692; Garrett & Mitchell, 2001, pp. 145-177);
- higher tax burden on non-residents in comparison to residents (Huizinga & Nielsen, 1997, pp. 149-165; Eijffinger & Wagner, 2002; Sørensen, 2000, pp. 429-472);
- heterogeneity of capital resulting in tax competition applying only to (more) mobile capital (Lee, 1997, pp. 222-242; Devereux *et al.*, 2008, pp. 451-495; Marceau *et al.*, 2010, pp. 249-259);
- heterogeneity of firms in their costs (Haufler & Stähler, 2009),
- compensation of tax revenue, lost as a result of competition, with other sources (from taxation of labor and consumption), ultimately ensuring long-term fiscal solvency (Mendoza & Tesar, 2005, pp. 163-204).

A promising direction of development of the theory replaces perfect competition with a monopolistic competition (with a prominent role of transaction costs, particularly transportation costs), assuming the existence of areas with fixed initial endowment of production factors, different in the centre and the periphery, and agglomeration effects, resulting in an increase in capital productivity where it is concentrated (Baldwin & Krugman, 2004, pp. 1-23). This effect reduces the negative effects of harmful tax competition and forces a tax increase even above the equilibrium tax rate proposed by the traditional theory of tax competition. Taxes are raised in the centre and remain low in the periphery. This model may assume migration from remote areas to agglomerations if cost-free international trade is permissible (Ludema & Wooton, 2000, pp. 331-357), asymmetric tax competition (Haufler & Wooton, 1999) or autonomous convergence – where convergence of economies takes place – of tax rates on the periphery to those in the centre (Borck & Pflüger, 2006, pp. 647-668). Few empirical studies testing the thesis of new economic geography confirm the impact of uneven distribution of infrastructure on presence and scope of tax competition (Bellak *et al.*, 2009, pp. 267-290; Mutti & Gruber, 2004, pp. 337-358).

The two main streams of the latest theories of international tax competition are – each partially reflected – in the actual data. Tax burden is transferred from capital to labor which is a postulate of the traditional theory of asymmetric tax competition, and the agglomeration tax effects are also observed (Kudła, 2013). Each group of models has therefore something to offer, which calls for an integration of the two approaches. Nevertheless, the traditional theory of tax competition between countries for the production factors or any of its extensions do not fully correspond to the actual conditions of taxation and give neither a satisfactory explanation of the problem of fiscal competition that would find confirmation in empirical data nor normative solutions for the shape of the optimal tax system. It seems that such a theory requires consideration of tax avoidance, the complexity of tax systems and fiscal solvency hypothesis. This paper integrates all three concepts.

The paper is structured as follows: in the first place the model of tax competition involving taxation of capital, labor and consumption is presented. The model captures the possibility of capital income shifting abroad and the foreign ownership of part of the capital invested in the country. Consumers can purchase foreign goods and services, and, in this way, avoid domestic taxation of consumption. Then the implicit model solutions are derived for the case where the constraints are not binding and subsequently for the cases limiting the borrowings of the government and the maximum level of taxes on consumption. The subsequent section describes the impact of debt parameters on capital, labor and consumption tax adjustment for the unconstrained model with selected functional form. It provides some interesting results on the fiscal response triggered by debt parameters and changes of other tax rates. The paper ends with a short conclusion.

Basic Model

As in Krogstrup (2004), a government is assumed to set tax rates on: capital income (τ_k), labor income (τ_w) and consumption (τ_c), to maximize the utility of a representative consumer (U), which is an increasing function of the size of consumption of the private good (c) and the public good (g):

$$\max_{\tau_k, \tau_w, \tau_c} U(c, g). \quad (1)$$

The consumer lives only by one period, so she has no reason to save and the whole consumer's income is spent on consumption. The consumption consists of domestic consumption taxed in home country and foreign consumption of goods z . Domestic consumption is financed by three sources of income: income of capital net of taxes, income of labor net of taxes and net repayment of debt. Capital employed in production in the country k is compensated at a level equal to its marginal productivity f_k (which is the derivative of production function f with respect to capital). Part α of capital is owned by the consumer, and the rest $(1 - \alpha)$ by a foreign residents. Only part of capital gains is taxed in the country (s), and the rest $(1 - s)$ is shifted abroad to avoid domestic taxation. Hence, the consumer receives $(1 - \tau_k)s\alpha f_k k$ of income from capital employed at home. The consumer is also the country's only labor force. The labor is immobile and therefore its supply is assumed to be constant \bar{l} . Labor is remunerated according to the marginal product f_l (the derivative of production function f with respect to l). Therefore, net income from labor is $(1 - \tau_w)f_l\bar{l}$. The consumer also receives income from the repayment of government debt ε , net of purchases of bonds b_t sold at a discount γ . The subscript t represents the value at the end of the year. Moreover, the sources of financing consumption are income earned abroad z . The latter parameter depends linearly on τ_c . Finally the formula for consumption takes the following form:

$$c = (1 - \tau_c)n[(1 - \tau_k)s\alpha f_k k + (1 - \tau_w)f_l\bar{l} + \varepsilon - \gamma b_t] + z, \quad (2)$$

where n is the share of the consumer's total income – a sum of domestic y_d and foreign y_{fn} income – spent in the country¹.

¹ This form of consumption function and parameter z should be explained in greater detail because it may seem unintuitive. Real private consumption is given by:

$$c = (1 - \tau_c)n(y_d + y_{fn}) + (1 - \tau_c^*)(1 - n)(y_d + y_{fn}),$$

$$c = [(1 - \tau_c)n + (1 - \tau_c^*)(1 - n)]y_d + [(1 - \tau_c)n + (1 - \tau_c^*)(1 - n)]y_{fn},$$

$$c = (1 - \tau_c)ny_d + (1 - \tau_c^*)(1 - n)y_d + [(1 - \tau_c) + (1 - \tau_c^*)\frac{1 - n}{n}]ny_{fn},$$

This formula determines taxes paid by the consumer to the government on:

- capital income not transferred abroad – $\tau_k s f_k k$,
- labor income – $\tau_w f_l \bar{l}$ and
- domestic consumption – $\tau_c n [(1 - \tau_k) s \alpha f_k k + (1 - \tau_w) f_l \bar{l} + \varepsilon - \gamma b_t]$.

In addition, the government receives tax revenues from consumption tax τ_c from purchases z^* made by foreigners $(\tau_c z^*)^2$, and those from the sale of bonds γb_t . It is assumed that foreign purchases in the home country z^* depend linearly on τ_c, τ_k . The government uses total revenues to provide public goods g and to pay off the debt ε :

$$g + \varepsilon = \tau_k s f_k k + \tau_w f_l \bar{l} + \tau_c n [(1 - \tau_k) s \alpha f_k k + (1 - \tau_w) f_l \bar{l} + \varepsilon - \gamma b_t] + \tau_c z^* + \gamma b_t$$

or (3)

$$g = \tau_k s f_k k + \tau_w f_l \bar{l} + \tau_c n [(1 - \tau_k) s \alpha f_k k + (1 - \tau_w) f_l \bar{l} + z^*] + (1 - \tau_c) (\gamma b_t - \varepsilon)$$

There are two limitations on fiscal policy. Firstly, the taxation of consumption cannot be too high ($\tau_c \leq \tau_{c \max} \rightarrow \tau_{c \max} - \tau_c \geq 0$). This can be justified by: political reasons (disagreement of voters), the negative impact of taxation on redistribution, high welfare loss (*dead-weight loss*), or legal restrictions (such as the upper limit of the VAT rate in the European Un-

where n describes the share of residents' income spent at home country and $n-1$ the share of residents' income spent abroad, y_d domestic income, y_{fn} foreign income and τ_c and τ_c^* are domestic and foreign consumption tax rates. The short final formula for consumption can be expressed as:

$$c = (1 - \tau_c) n y_d + z,$$

where $z = (1 - \tau_c^*) (1 - n) y_d + [(1 - \tau_c) + (1 - \tau_c^*) \frac{1 - n}{n}] n y_{fn}$. Each of the two parts of the formula contains variables (τ_c^* , n or y_{fn}) which we treat as beyond the control of the home country government. Eventually, we obtain the equation (2):

$$c = (1 - \tau_c) n y_d + z \equiv (1 - \tau_c) n [(1 - \tau_k) s \alpha f_k k + (1 - \tau_w) f_l \bar{l} + \varepsilon - \gamma b_t] + z.$$

² Consumption is assumed to be taxed on the origin principle. Although it is the destination principle that is generally applied (e.g. in European Union), the origin principle is practiced in border trade and retail electronic commerce.

ion). If the consumption tax could be arbitrarily high, then the government would confiscate the value of consumption and redistribute it amongst consumers. Potentially, such a policy could allow for provision of public goods without distorting the allocation of production factors. We assume that the latter policy is not available for the government because of rapidly rising cost of the high consumption tax.

Secondly, there is a maximum interest rate that the government is able to pay for debt servicing ($r_\varepsilon \leq r_{\varepsilon \max} \rightarrow r_{\varepsilon \max} - r_\varepsilon \geq 0$). Above this threshold value all borrowing by the government is discontinued ($b_t = 0$), and the budget must be balanced³. The interest rate depends on the taxation level of capital, labor and consumption and the size of the original debt ε . However the direction of this impact is not pre-determined. Higher tax rates can increase fiscal solvency and the credibility of government as well as they can signal problems with budget balancing.

The possibility of borrowing by the government sheds new light on the tax-mix policy. Purchases of bonds are – unlike taxes – voluntary, which mean that the sign $\varepsilon - \mathcal{P}_t$ is not pre-determined. It might seem that the consumer would prefer the difference to be positive, but then he runs the risk of higher taxation of capital, labor or consumption that is not neutral. If, however, the consumer agrees that $\varepsilon - \mathcal{P}_t$ is negative, then it is possible to lower taxes and to reduce the distortion caused by them. In the latter situation bond purchases are a voluntary payment hampering the distortion of consumption generated by taxation.

The optimization problem can be written as a Lagrange function:

$$L(\tau_k, \tau_w, \tau_c) = U(c, g) + \lambda(\tau_{c \max} - \tau_c) + \mu(r_{\varepsilon \max} - r_\varepsilon). \quad (4)$$

Therefore the necessary (Kuhn-Tucker) conditions are as follows:

1.

$$L_{\tau_k} = U_c c_{\tau_k} + U_g g_{\tau_k} + \mu(r_{\varepsilon \max} - r_\varepsilon)_{\tau_k} = 0$$

³ In practice, as demonstrated by the examples of Italy and Spain during the sovereign debt crisis, it may be approximately 7% per year if it is persistent.

$$L_{\tau_k} = U_c (1 - \tau_c) n \left\{ s \alpha k (1 - \tau_k - f_k) - \frac{\partial(\gamma_t)}{\partial \tau_k} + (1 - \tau_w) \bar{l} \frac{f_k}{f_{kk}} + (1 - \tau_k) \frac{f_k}{f_{kk}} \alpha s \right\} +$$

$$U_g \left\{ \begin{aligned} & \left(\tau_w + (1 - \tau_w) \tau_c n \right) \bar{l} \frac{f_k}{f_{kk}} + s k [\tau_k + f_k + \alpha \tau_c n (1 - \tau_k - f_k)] - \tau_c \frac{\partial(\gamma_t)}{\partial \tau_k} + \frac{\partial(\gamma_t)}{\partial \tau_k} + \\ & \left[\tau_k + \tau_c n (1 - \tau_k) \right] s \alpha \frac{f_k}{f_{kk}} + \tau_c n \left[\frac{\partial z^*}{\partial \tau_k} + \frac{\partial z^*}{\partial k} \frac{1}{f_{kk}} \right] \end{aligned} \right\} - \mu \frac{\partial r_\varepsilon}{\partial \tau_k} = 0$$

2.

$$L_{\tau_w} = U_c c_{\tau_w} + U_g g_{\tau_w} + \mu (r_{\varepsilon \max} - r_\varepsilon)_{\tau_w} = 0$$

$$L_{\tau_w} = U_c (1 - \tau_c) n \left\{ -\frac{\partial(\gamma_t)}{\partial \tau_w} - f_l \bar{l} \right\} + U_g \left\{ (1 - \tau_c) \frac{\partial(\gamma_t)}{\partial \tau_w} + (1 - n \tau_c) f_l \bar{l} \right\} - \mu \frac{\partial r_\varepsilon}{\partial \tau_w} = 0$$

3.

$$L_{\tau_c} = U_c c_{\tau_c} + U_g g_{\tau_c} + \lambda (\tau_{c \max} - \tau_c)_{\tau_c} + \mu (r_{\varepsilon \max} - r_\varepsilon)_{\tau_c} = 0$$

$$L_{\tau_c} = U_c \left\{ -n [(1 - \tau_k) f_k s \alpha k + \varepsilon - \gamma_t + (1 - \tau_w) f_l \bar{l}] - (1 - \tau_c) n \frac{\partial(\gamma_t)}{\partial \tau_c} + \frac{dz}{d\tau_c} \right\} +$$

$$U_g \left\{ n [(1 - \tau_k) f_k s \alpha k + \varepsilon - \gamma_t + (1 - \tau_w) f_l \bar{l} + z^*] + n \tau_c \frac{\partial z^*}{\partial \tau_c} - (\gamma_t - \varepsilon) + (1 - \tau_c) \frac{\partial(\gamma_t)}{\partial \tau_c} \right\} - \lambda - \mu \frac{\partial r_\varepsilon}{\partial \tau_c} = 0$$

4.

$$L_\lambda = (\tau_{c \max} - \tau_c) \geq 0 \text{ and } \lambda \geq 0 \text{ and } (\tau_{c \max} - \tau_c) \lambda = 0$$

5.

$$L_\mu = (r_{\varepsilon \max} - r_\varepsilon) \geq 0 \text{ and } \mu \geq 0 \text{ and } (r_{\varepsilon \max} - r_\varepsilon) \mu = 0$$

The Optimal Taxation

Consider first a solution where both constraints are not binding, and therefore the consumption tax rate can be set arbitrarily, while the cost of debt is lower than the maximum (when $\mu = 0$ and $\lambda = 0$). Then, the marginal rates of substitution between public good and private one are as follows:

$$\frac{U_g}{U_c} = \frac{(1-\tau_c)n \left\{ s\alpha k(1-\tau_k - f_k) - \gamma \frac{\partial r_\varepsilon}{\partial \tau_k} \left[\frac{db_t}{dr_\varepsilon} - b_t \right] + (1-\tau_w)\bar{l} \frac{f_{lk}}{f_{kk}} + (1-\tau_k) \frac{f_k}{f_{kk}} \alpha \right\}}{\left\{ (\tau_w + (1-\tau_w)\tau_c)n \bar{l} \frac{f_{lk}}{f_{kk}} + s[\tau_k + f_k + \alpha \tau_c n(1-\tau_k - f_k)] + (1-\tau_c)\gamma \frac{\partial r_\varepsilon}{\partial \tau_k} \left[\frac{db_t}{dr_\varepsilon} - b_t \right] \right.} \quad (5a)$$

$$\left. + [\tau_k + \alpha \tau_c n(1-\tau_k)]s \frac{f_k}{f_{kk}} + \tau_c n \left[\frac{\partial z^*}{\partial \tau_k} + \frac{\partial z^*}{\partial k} \frac{1}{f_{kk}} \right] \right\}}$$

(from derivative L_{τ_k})

$$\frac{U_g}{U_c} = \frac{(1-\tau_c)n \left\{ \gamma \frac{\partial r_\varepsilon}{\partial \tau_w} \left[\frac{db_t}{dr_\varepsilon} - b_t \right] + f_l \bar{l} \right\}}{(1-\tau_c)\gamma \frac{\partial r_\varepsilon}{\partial \tau_w} \left[\frac{db_t}{dr_\varepsilon} - b_t \right] + (1-n\tau_c)f_l \bar{l}} \quad (5b)$$

(from derivative L_{τ_w})

$$\frac{U_g}{U_c} = \frac{n \left[(1-\tau_k)f_k s\alpha k + \varepsilon_t - \eta_t + (1-\tau_w)f_l \bar{l} \right] + (1-\tau_c)n\gamma \frac{\partial r_\varepsilon}{\partial \tau_c} \left[\frac{db_t}{dr_\varepsilon} - b_t \right] \frac{dz}{d\tau_c}}{n \left[(1-\tau_k)f_k s\alpha k + \varepsilon_t - \eta_t + (1-\tau_w)f_l \bar{l} + z^* \right] + n\tau_c \frac{\partial z^*}{\partial \tau_c} - (\eta_t - \varepsilon_t) + (1-\tau_c)\gamma \frac{\partial r_\varepsilon}{\partial \tau_c} \left[\frac{db_t}{dr_\varepsilon} - b_t \right]} \quad (5c)$$

(from derivative L_{τ_c})

The efficient level of public good provision requires the marginal rate of substitution to be equal to 1. One can see (from 5b) that MRS is equal to 1 only when $n = 1$ (there is no foreign consumption of residents – which is an

equivalent of closed economy) or when $\tau_c = 1 + \frac{f_l \bar{l}}{\gamma \frac{\partial r_\varepsilon}{\partial \tau_w} \left[\frac{db_t}{dr_\varepsilon} - b_t \right]}$. There-

fore the efficient level of public good provision can be obtained by appropriately setting the tax rate on consumption. However, for reasonable signs of parameters, the consumption tax can be lower than 100% only when $\frac{\partial r_\varepsilon}{\partial \tau_w} > 0$. It means that the interest on debt has to rise with the labor tax rate.

The labor tax rate and the capital tax rate are interrelated but one of these rates can be set freely. This condition is implied by the equalization of (5c) with 1 (the condition for efficient public good provision) producing the formula without τ_k and τ_w . Computing $\frac{db_t}{dr_\varepsilon} - b_t$ and inserting it into equation 5a we can get the implicit formula for τ_k (as a function of τ_w):

$$\tau_k = - \frac{\{\alpha n s(f_k + k f_{kk}) + f_{lk} \bar{l} [n + (1-n)\tau_w] + s k f_k (1-\alpha n)\} \frac{\partial r_\varepsilon}{\partial \tau_w} - f_{kk} (1-n) f_l \bar{l} \frac{\partial r_\varepsilon}{\partial \tau_k}}{(1-\alpha n) s(f_k + k f_{kk}) \frac{\partial r_\varepsilon}{\partial \tau_w}} \quad (6)$$

$$- \frac{\{(1-n) f_l \bar{l} \frac{\partial r_\varepsilon}{\partial \tau_c} + [(\gamma b_t - \varepsilon) - \frac{\partial z}{\partial \tau_c} - n z^*] \frac{\partial r_\varepsilon}{\partial \tau_w}\} \left(\frac{\partial z^*}{\partial k} + f_{kk} \frac{\partial z^*}{\partial \tau_k} \right)}{(1-\alpha n) s(f_k + k f_{kk}) \frac{\partial r_\varepsilon}{\partial \tau_w} \frac{\partial z^*}{\partial \tau_c}}$$

As one can see, the relation between tax on capital and tax on labor is complicated. Nevertheless, assuming $\frac{\partial r_\varepsilon}{\partial \tau_w}$ to be constant and other derivatives of r_ε independent on τ_w (this is an equivalent of r_ε separable with respect to tax rates) the derivative of (6) by τ_w takes a simple form of:

$$\frac{\partial \tau_k}{\partial \tau_w} = - \frac{f_{lk} \bar{l} (1-n)}{(1-\alpha n) s(f_k + k f_{kk})} \quad (7)$$

The sign of this derivative is determined by the sign of $f_k + kf_{kk}$. When the latter is negative ($f_k < -kf_{kk}$), then both tax rates (on labor and on capital) are expected to change in the same direction. The last condition can be fulfilled when marginal productivity of capital rapidly decreases with capital accumulation, so for the relatively low level of accumulated capital.

Properties of Binding Constraint Solutions

If the constraints are binding, there are three possible options.

In the first one, the constraint on the cost of debt service is binding and the constraint on tax expenditures is disabled, that is $\mu > 0$ and $\lambda = 0$ ($r_\varepsilon = r_{\varepsilon\max}$ and $\tau_c < \tau_{c\max}$). Additionally, when $r_\varepsilon = r_{\varepsilon\max}$, the government is no longer able to borrow on the financial market ($b_t = 0$), so the equilibrium requires higher tax rates to repay the debt (obviously only if $\varepsilon > 0$). Now the MRS are:

$$\frac{U_g}{U_c} = - \frac{(1-\tau_c)n \left\{ s\alpha k(1-\tau_k - f_k) + (1-\tau_w)\bar{l} \frac{f_{lk}}{f_{kk}} + (1-\tau_k) \frac{f_k}{f_{kk}} \alpha s \right\}}{\left\{ (\tau_w + (1-\tau_w)\tau_c n) \bar{l} \frac{f_{lk}}{f_{kk}} + sk[\tau_k + f_k + \alpha\tau_c n(1-\tau_k - f_k)] \right.} \quad (8a)$$

$$\left. + [\tau_k + \alpha\tau_c n(1-\tau_k)] s \frac{f_k}{f_{kk}} + \tau_c n \left[\frac{\partial z^*}{\partial \tau_k} + \frac{\partial z^*}{\partial k} \frac{1}{f_{kk}} \right] \right\}}$$

(from derivative L_{τ_k})

$$\frac{U_g}{U_c} = \frac{(1-\tau_c)n}{(1-n\tau_c)} \quad (8b)$$

(from derivative L_{τ_w})

and finally

$$\frac{U_g}{U_c} = \frac{n[(1-\tau_k)f_k s \alpha k + \varepsilon + (1-\tau_w)f_l \bar{l}] - \frac{dz}{d\tau_c}}{n[(1-\tau_k)f_k s \alpha k + \varepsilon + (1-\tau_w)f_l \bar{l} + z^*] + n\tau_c \frac{\partial z^*}{\partial \tau_c} + \varepsilon} \quad (8c)$$

(from derivative L_{τ_c}).

Immediately it is seen (from 8b) the equilibrium is no longer efficient for any τ_c with the exception of $n = 1$ (closed economy). Therefore if the maximum-debt-interest constraint is binding, taxation cannot be set at an efficient level even with three available tax instruments. Equalizing (8a) with (8b), and (8b) with (8c) one can find formulas for τ_k and τ_w as functions of τ_c . The results are not easy to interpret but one thing is striking – the tax rate on capital does not depend on the debt repayment ε . It implies that any changes of debt payments trigger only adjustment of the tax on consumption and the tax on labor without affecting capital.

In the second case, the upper limit of the consumption tax rate is binding and the interest rate on bonds can be freely set on the financial market, i.e. $\mu = 0$ and $\lambda > 0$ ($r_\varepsilon < r_{\varepsilon \max}$ and $\tau_c = \tau_{c \max}$). This means that the government has only two tax tools: the taxes on capital and labor because the consumption tax is set fixed. The marginal rates of substitution then look as follows:

$$\frac{U_g}{U_c} = \frac{(1-\tau_c)n \left\{ s \alpha k (1-\tau_k - f_k) - \gamma \frac{\partial r_\varepsilon}{\partial \tau_k} \left[\frac{dh}{dr_\varepsilon} - b_l \right] + (1-\tau_w) \bar{l} \frac{f_{lk}}{f_{kk}} + (1-\tau_k) \frac{f_k}{f_{kk}} \alpha \right\}}{\left\{ (\tau_w + (1-\tau_w)\tau_c n) \bar{l} \frac{f_{lk}}{f_{kk}} + s k [\tau_k + f_k + \alpha \varphi n (1-\tau_k - f_k)] + (1-\tau_c) \gamma \frac{\partial r_\varepsilon}{\partial \tau_k} \left[\frac{dh}{dr_\varepsilon} - b_l \right] \right\}} \quad (9a)$$

$$\left\{ + [\tau_k + \alpha \varphi n (1-\tau_k)] s \frac{f_k}{f_{kk}} + \tau_c n \left[\frac{\partial z^*}{\partial \tau_k} + \frac{\partial z^*}{\partial k} \frac{1}{f_{kk}} \right] \right\}$$

(from derivative L_{τ_k})

as well as:

$$\frac{U_g}{U_c} = \frac{(1-\tau_c)n \left\{ \gamma \frac{\partial r_\varepsilon}{\partial \tau_w} \left[\frac{db_t}{dr_\varepsilon} - b_t \right] + f_l \bar{l} \right\}}{(1-\tau_c) \gamma \frac{\partial r_\varepsilon}{\partial \tau_w} \left[\frac{db_t}{dr_\varepsilon} - b_t \right] + (1-n\tau_c) f_l \bar{l}} \quad (9b)$$

(from derivative L_{τ_w}).

As in the previous case, the marginal rate of substitution is not equal to one (with exception of $n = 1$) because of (9b). The scarcity of tax revenues from the consumption tax has to be compensated by labor or capital taxation. The tax rate on labor τ_w can be expressed as a function of τ_k and $\tau_{c\max}$ (or τ_k as a function of τ_w and $\tau_{c\max}$). These functions only indirectly depend on the debt parameters, namely by $\frac{\partial r_\varepsilon}{\partial \tau_w}$ and $\frac{db_t}{dr_\varepsilon} - b_t$. If these derivatives are constant then the debt has no impact on taxation.

In the third case both constraints are binding $\mu > 0$ and $\lambda > 0$ ($r_\varepsilon = r_{\varepsilon\max}$ and $\tau_c = \tau_{c\max}$) and then:

$$\frac{U_g}{U_c} = \frac{(1-\tau_c)n \left\{ s \alpha k (1-\tau_k - f_k) + (1-\tau_w) \bar{l} \frac{f_{lk}}{f_{kk}} + (1-\tau_k) \frac{f_k}{f_{kk}} \alpha s \right\}}{\left\{ (\tau_w + (1-\tau_w)\tau_c n) \bar{l} \frac{f_{lk}}{f_{kk}} + s k [\tau_k + f_k + \alpha \tau_c n (1-\tau_k - f_k)] \right.} \quad (10a)$$

$$\left. + [\tau_k + \alpha \tau_c n (1-\tau_k)] s \frac{f_k}{f_{kk}} + \tau_c n \left[\frac{\partial z^*}{\partial \tau_k} + \frac{\partial z^*}{\partial k} \frac{1}{f_{kk}} \right] \right\}}$$

(from derivative L_{τ_k})

and

$$\frac{U_g}{U_c} = \frac{(1-\tau_c)n}{(1-n\tau_c)}. \quad (10b)$$

(from derivative L_{τ_w}).

In this situation, the tax rate on labor income is arbitrary and the tax on capital is a function of the maximum consumption tax rate. In the latter case, none of the debt parameters affect the tax rates. The taxation is solely determined by the form of the production function and the reaction of foreign purchases in the home country on invested capital and on the domestic taxation of capital. However, this relation is implicit (the tax is a function of reaction to the tax) so detailed features of solution depend on the specific functional form of foreign reaction to the home taxation.

The binding constraints make the equilibrium inefficient and distort the tax rate setting. The linkage of tax parameters with debt changes is strictly limited. In the first case, the debt repayment affects only the labor and consumption taxes. In the second case, only the debt cost r_e is responsible for the tax adjustment, whereas in the third case there is no impact of the debt on the tax rates. Therefore, it seems reasonable to concentrate more on the features of unconstrained case with a selected functional form. This could help to scrutinize the effects of changing debt parameters in details and to investigate the explicit form of solution.

An Illustratory Explicit Solution

The general formula for capital taxation (6) includes the implicit interdependences and to say more about impact of direction of parameters it is necessary to calculate the value of the tax rates for a specific functional form. In order to get the explicit formula for τ_k , the following production function is assumed: $f(k, l) = okl - dk^2 - jl^2$, $o, d, j > 0$. This form provides the possibility of complementarity and substitutability between capital and labor and preserves the signs of the first and second derivatives in line with common assumptions (the positive first-order derivatives with respect to k and l , the negative second-order derivatives with the exception of mixed derivatives by k and l). Moreover, this type of function does not apply the power of parameter different from 1 (like, for example, Cobb-Douglas or CES functions) and, therefore, is easy to calculate and transform. The function of foreign purchases in the home country is assumed to be linear and negatively depends on tax rates at home country: $z^* = u\tau_k + m\tau_c + v$, $u, m < 0, v > 0$. The foreign purchases in the country include the exogenous component v which is positive and represents a tax-insensitive part of foreign purchases of domestic goods and capital. This allows z^* to be positive. The taxes imposed on capital and

consumption decrease the foreign purchases because they raise the cost of domestic goods. The purchases abroad are equal to: $z = c_1 + c_2 \tau_c$, $c_1, c_2 > 0$ because we do not consider the foreign taxes. The high consumption tax at home induces domestic consumers (residents) to buy more foreign goods. The supply of capital is a negative linear function of capital tax rate: $k = \beta - \delta \tau_k$, $\beta, \delta > 0$, because owners of capital are discouraged by the imposed tax to accumulate capital. Together these functions imply the derivatives of foreign consumption at home country to be equal to: $\frac{\partial z^*}{\partial \tau_k} = u$ and $\frac{\partial z^*}{\partial k} = -\frac{u}{\delta}$ because $\frac{\beta - k}{\delta} = \tau_k$. Finally, the impact of tax rates changes on the cost of the debt is constant for all tax rates: $\frac{\partial r_\varepsilon}{\partial \tau_w} = rw$, $\frac{\partial r_\varepsilon}{\partial \tau_c} = rc$ and $\frac{\partial r_\varepsilon}{\partial \tau_k} = rt$. This allows for calculation (from 6) of the following formula on the capital tax rate:

$$\tau_k = \frac{rt2d\delta m(1-n)(2jl-ko)}{rw[\delta ms(lo-4dk)(1-\alpha n) + nu^2(2d\delta+1)]} - \frac{rc(1-n)ul(2jl-ko)(1+2d\delta)}{rw[\delta ms(lo-4dk)(1-\alpha n) + nu^2(2d\delta+1)]} + \tag{11}$$

$$\frac{2d\delta kms[2\alpha n + (lo-2dk)(1-\alpha n)] - u(1+2d\delta)[c2 + \varepsilon - \gamma b_i + n(cm+v)]}{\delta ms(lo-4dk)(1-\alpha n) + nu^2(2d\delta+1)} - \frac{\delta mn\alpha(1+as)}{\delta ms(lo-4dk)(1-\alpha n) + nu^2(2d\delta+1)} - \frac{\delta m\alpha(1-n)\tau_w}{\delta ms(lo-4dk)(1-\alpha n) + nu^2(2d\delta+1)}$$

It should be noted that constant reaction of r_ε to the tax rates changes (rw , rc or rt) does not affect the relation between τ_k and τ_w . Precisely, the derivative of τ_k with respect to τ_w has the following form:

$$\frac{\partial \tau_k}{\partial \tau_w} = - \frac{\delta mo(1-n)}{\delta ms(lo-4dk)(1-\alpha n) + nu^2(2d\delta+1)} \quad (12)$$

which is independent of rw , rc and rt .

All three latter derivatives are expected to be positive to ascertain the efficiency of public goods provision (because this condition requires $rw > 0$). Therefore (from 11) capital taxation is always positively affected by one and negatively by the other derivative of r_ε . For example, the capital tax should be enlarged by the impact of $\frac{\partial r_\varepsilon}{\partial \tau_k}$ and, simultaneously, re-

duced by the impact of $\frac{\partial r_\varepsilon}{\partial \tau_c}$ (if $2jl - ko < 0$). The relation turns opposite if and only if $2jl - ko > 0$. The last condition measures the effect of decreasing labor productivity and the relative strength of complementarity effect between labor and capital. The first case is more likely in contemporary economies confirming substitutability of consumption and capital taxation. If the derivatives of r_ε are all equal in the equilibrium⁴ then the capital taxation stays unaffected by them (all derivatives in 11 cancel out).

The sign of the relation between the capital and labor taxes (12) is determined by the sign of $lo - 4dk$ (because the nominator is always negative and preceded by minus and the only part of the denominator which can

⁴ In equilibrium these three derivatives are expected to be equal to each other ($\frac{\partial r_\varepsilon}{\partial \tau_k} = \frac{\partial r_\varepsilon}{\partial \tau_w} = \frac{\partial r_\varepsilon}{\partial \tau_c}$ or $rt = rw = rc$). If they were not, then the tax rate affecting the

interest rate payments the most could be slightly higher and the remaining rates could be slightly lower, resulting in a lower cost of debt repayment. Such a change would be the most efficient way of debt interest cost cutting. Therefore, all three tax rates should be perfectly substitutable with respect to the interest rate on debt, to hold the composition of tax rates unaltered.

be negative is just $lo - 4dk$). If $lo - 4dk < 0$, then the tax on labor moves in the same direction as the tax on capital. The opposite is true for $lo - 4dk > 0$ and $\delta ms(lo - 4dk)(1 - \alpha n) < -nu^2(2d\delta + 1)$. Particularly, the first case is possible when d is large or o is small. Small o hints the low complementarity of labor and capital. Large d represents the negative effect of capital stock on its remuneration. These conditions seem to be unlikely for contemporary economies, where capital and labor complement each other and the remuneration of capital is relatively stable. Therefore, the basic case should include $lo - 4dk > 0$ providing ambiguous result for common direction of capital and labor taxation. However, if n is sufficiently low (the share of residents' income spent at home country is negligible - the case of high internalization), then the condition ($\delta ms(lo - 4dk)(1 - \alpha n) < -nu^2(2d\delta + 1)$) is met and the two tax rates move in opposite directions. For high level of n and α (a small level of international consumption and a large level of home country ownership of capital - low internalization case) the condition is not met and both tax rates' changes are conforming.

The fundamental problem during a crisis is the reaction of the tax rates to changes of the debt ε . If market investors do not approve of the government revenues-to-debt ratio, they will require higher interest payments (higher yield) on the new offer of government bonds or they will reject such a proposition completely⁵. In short, we can say that during the crisis tax revenues should be affected by the characteristics of the public debt. Therefore, considering the crisis time adjustment, we concentrate on the tax responses induced by debt included in the impact of ε and γ or b_t . The derivative of (11) with respect to ε has relatively straightforward form:

$$\frac{\partial \tau_k}{\partial \varepsilon} = - \frac{u(2d\delta + 1)}{\delta ms(lo - 4dk)(1 - \alpha n) + nu^2(2d\delta + 1)} \quad (13)$$

Like before, the reaction of the capital tax to the change of debt payments (ε) is positive when $lo - 4dk < 0$ or $lo - 4dk > 0$ and $\delta ms(lo - 4dk)(1 - \alpha n) < -nu^2(2d\delta + 1)$. Therefore, we expect an increase in the tax rate on capital after the increase of debt payments, if capi-

⁵ It means the requirement of yield mentioned above pertains to the financial capacity of the government.

tal is possessed mainly by residents and the share of foreign consumption is not very high. The opposite relation is true for the increase of γ :

$$\frac{\partial \tau_k}{\partial \gamma} = \frac{u(2d\delta + 1)b_t}{\delta ms(lo - 4dk)(1 - \alpha n) + nu^2(2d\delta + 1)} \quad (14)$$

Lowering the discount on bonds (increasing γ) decreases the tax on capital if $lo - 4dk < 0$ or $lo - 4dk > 0$ and $\delta ms(lo - 4dk)(1 - \alpha n) < -nu^2(2d\delta + 1)$. The same conclusion is true for b_t .

Solving (11) for τ_w and calculating the derivatives of ε and γ , we receive the response of the labor tax on the parameters of the debt:

$$\frac{\partial \tau_w}{\partial \varepsilon} = -\frac{u(2d\delta + 1)}{lmo\delta(1 - n)} \quad (15)$$

$$\frac{\partial \tau_w}{\partial \gamma} = \frac{u(2d\delta + 1)b_t}{lmo\delta(1 - n)} \quad (16)$$

The first reaction is negative (15), and the second (16) positive. In accordance with the previous results, the increase of debt payments should decrease the tax on labor and for moderate levels of international consumption and foreign ownership of domestic capital it should adversely affect the capital taxation. In the high internalization case (high level of consumption abroad and capital possessed in great extent by non-residents), the tax on capital should be greater. Lowering discount (higher γ) increases taxation of labor but has ambiguous impact on capital taxation. For low 'internalization' it increases the tax, but for high – decreases it. It should be stressed that these results are different from those for the debt interest because the debt interest moves the tax on labor in the same direction (in other words, increase of the interest on debt r_e providing the same adjustment as lower γ despite the latter is not directly affected by the tax rates). The same result as for γ applies to b_t .

In the same convention we can calculate formula for τ_c from

$$\tau_c = 1 + \frac{f_l \bar{l}}{\gamma \frac{\partial r_\varepsilon}{\partial \tau_w} \left[\frac{db_t}{dr_\varepsilon} - b_t \right]} \text{ in the explicit form, as a function of } \tau_k :$$

$$\tau_c = -\frac{rc(1-n)(klo - 2jl^2)}{rw2mn} - \frac{c2 + \varepsilon - \gamma b_t}{2mn} - \frac{u\tau_k + v}{2m} \quad (17)$$

and compute the respective derivatives of ε and γ :

$$\frac{\partial \tau_c}{\partial \varepsilon} = -\frac{1}{2mn} \quad (18)$$

$$\frac{\partial \tau_c}{\partial \gamma} = \frac{b_t}{2mn} \quad (19)$$

According to the obtained results the tax on consumption should change in the opposite direction than the tax on capital. The consumption tax on should increase when debt payments are increasing and get lower when the discount rate is diminishing (γ is increasing). The latter is also valid for b_t . Because the reaction of τ_k on debt payments depends on the internalization level one can expect the total increase of the consumption tax will be modified by the adjustment of the capital tax rate. This implies a higher increase of the consumption tax when the level of economy's internalization is high (because in this case change of the capital tax is negative).

Conclusions

The paper raises the issue of optimal fiscal policy in an open economy when capital is mobile and, unlike labor, capital income can be shifted abroad and consumers may freely trade cross-border. To finance public goods the government can impose taxes on labor, capital and consumption or issue bonds.

When fiscal policy is by no means unfettered then efficient provision of public goods requires the labor tax to be positively affected by the interest paid on the public debt. This is the consequence of solvency requirement. At the same time, if we consider an adjustment to changes of the debt ser-

vicing cost, the tax on labor should be lowered. The consumption tax should be fixed to ascertain an efficient level of public goods. If the internalization of economy is high, then increasing debt servicing cost induces a decrease in both labor and capital taxes. If the internalization level is low, then the tax on capital should go up and the tax on labor should drop after an increase in debt servicing cost. In the same situation, the consumption tax should go up as well. The reaction of the consumption tax is moderated by a change of the capital tax because the taxes on capital and on consumption are interdependent and substitutive. The higher tax on consumption suppresses an increase in the tax on capital. This can induce the choice of the consumption tax as a preferred tool for tax adjustment when budgetary problems intensify. This is because the consumption tax is less distortionary than capital taxation. The reaction on the bond's discount changes (or the value of bond issuance) is opposite to the described debt servicing cost changes. It points out that adjustment to the new debt level is possible but it distorts allocation between private and public goods.

If there was a maximum interest rate that the government would be able to pay for servicing debt, the equilibria of the tax rates turn out to be inefficient. In this case capital taxation is not an instrument for fiscal adjustment and the fiscal policy has to concentrate on taxes imposed on labor and consumption. If, on the other hand, there was an upper limit imposed on the consumption tax rate and the bonds interest rate could be freely set on the financial market, then the consumption tax rate would be set at the maximum but not optimal (higher) level and the resulting scarcity of tax revenues should be compensated by the labor tax or the capital tax, with preference to the former. In this situation the impact of debt is limited to the debt interest because the size of debt servicing cost is irrelevant to the tax rates. Finally, when both constraints are binding then the debt changes cannot be adjusted by the tax changes. All three cases are inefficient in public good provision.

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