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TAX RATES IMPACT ON GDP IN POLAND

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Abstract: *In the article tax rates impact on GDP in Poland is analysed. The analysis is based on dynamic stochastic general equilibrium model (DSGE model). Impulse-response analysis shows that the increase in income tax rate causes the decrease in capital, labour and production. Moreover capital is partially replaced by consumption, because households minimise consumption fluctuations. The comparison of effects of increasing taxation of the capital and labour shows that the impact on economy is stronger in case of wage taxes. Consumption taxes, by negative wealth effect, decrease after-tax consumption and capital but on the other hand increase labour and production. The direction of impact of consumption taxes on production is in this case opposite than in demand models.*

INTRODUCTION

In a time of crisis, in order to control the deficit in public budget, it may be necessary to increase the tax burden. At the same time, however, changes in taxation significantly affect economic activity. Hence, the purpose of the paper is to analyze the impact of tax rate changes on the main macroeconomic variables in the Polish economy.

The following research hypotheses have been verified in the paper:
− Higher tax rates negatively affect GDP,
− Income tax changes have stronger impact on the capital than on the employment,
− Increased taxation of income from capital has a stronger impact on production than raising taxes on wages.

Verification of hypotheses was based on supply-side dynamic stochastic general equilibrium model (DSGE model). It is assumed in DSGE models that households take such decisions concerning the extent of consumption and leisure to maximize the expected value of the discounted sum of consumption and leisure utility. In supply-side DSGE models (real business cycle models) it is also assumed that wages and prices are perfectly flexible and immediately adapt to the market equilibrium (cf. Hansen 1985; Ljungqvist, Sargent 2004). According to real business cycle models, economic fluctuations are the result of changes in the optimal size of production, resulting from rational decisions of households (Plosser 1989; Stadler 1994). Households take capital stock and TFP level as given and make such choices that maximize the expected value of discounted utilities. While specifying the number of hours of work the households determine the amount of leisure. At the same time the choice of consumption determines how much income can be spent on investment, and this, in turn, determines the future capital stock.

In many cases, the constructed theoretical model based on statistical data, is econometrically verified. The real business cycle models often do not examine if the data resulting from the model matches empirical data. This is due in part to the fact that RBC models are very general and do not include the many distortions that occur in the real economy and significantly affect the values of variables. At the same time, the levels of variables in RBC models are very sensitive to small changes in assumptions. As a result, recognizing that the model matches the actual data as the most important criterion, allows estimating equations indeed well matched within the sample, but does not reflect the economic relationships and is not suitable for forecasting beyond the sample. Therefore, RBC models instead of estimation based on real data often use simulations based on artificial data, generated on the basis of the model equations (see e.g. Snowdon, Vane, Wynarczyk 1998). The

values of parameters have important impact on the formation of model variables' characteristics. These values can be obtained by calibration (see e.g. Summers 1986), which was applied in this paper. Calibration involves choosing such values of the parameters which are economically justified and make the model generate the data with stochastic characteristics resembling fluctuations in the real economy.

The structure of the article is as follows: First, the assumptions of the model are presented. Then, the results of the model with one taxation rate are presented. Subsequently the effects of pro-cyclical or counter-cyclical tax policy are presented, as well as the impact of different types of taxes. The paper ends with a summary and main conclusions. It was found during the study that the increased tax rates decrease capital and employment, and consequently decrease production. In addition, the model shows that the increased taxes on wages have stronger negative impact on GDP than taxation on income from capital.

THEORETICAL MODEL

The analyzed DSGE model is based on the following assumptions:

1. The budget revenues consist of distortionary taxation (taxes proportional to income) and lump-sum taxes. Among public expenditures government spending and transfers are distinguished. Under these assumptions the government budget constraint is given by the following equation:

$$\sum_{t=1}^{\infty} \frac{1}{\prod\limits_{j=1}^{t}\left(1+(1-\tau_j)r_j\right)}g_t =$$
$$= \sum_{t=1}^{\infty} \frac{1}{\prod\limits_{j=1}^{t}\left(1+(1-\tau_j)r_j\right)}\left(\tau_t y_t + LS_t - Tr_t\right) ,$$

where:

τ_t – income tax rate (the same for capital and labour income);

LS_t – lump sum taxes;

y_t – income (output);

g_t – government spending on goods and services;

Tr_t – transfers;

r_t – interest rate.

2. Households maximize the expected value of the discounted sum of utilities:

$$U = E\left(\sum_{t=0}^{\infty} \beta^t \left(\ln(c_t + \phi h_t)\right)\right).$$

where:

c_t – consumption;

h_t – leisure;

β – discount factor, $\beta \in (0,1)$;

ϕ – weight given to leisure, $\phi > 0$.

3. The households budget constrain is given by the following equation:

$$\sum_{t=1}^{\infty} \frac{1}{\prod_{j=1}^{t}\left[1+(1-\tau_j)r_j\right]}\left[c_t + (1-\tau_t)w_t(1-l_t)\right]=$$

$$k_0 + \sum_{t=1}^{\infty} \frac{1}{\prod_{j=1}^{t}\left[1+(1-\tau_j)r_j\right]}\left[(1-\tau_t)w_t - LS_t + Tr\right]$$

,

where:

k_t - capital;

w_t - wages;

l_t - labour supply.

One can notice that the household intertemporal budget constraint depends on lump taxes, so ricardian equivalence is not fulfilled in this model (c.f. Barro 1974, Tobin 1978).

4. The capital changes in accordance with the equation standard growth of capital formula:

$$\Delta k_{t+1} = i_t - \delta k_t ,$$

where:

i_t – investment,

δ – depreciation rate, $\delta \in (0,1)$.

5. Closed economy is analyzed in the model so the aggregate demand takes form:

$$c_t + i_t + g_t = y_t ,$$

thus:

$$c_t = y_t + (1 - \delta)k_t - k_{t+1} - g_t .$$

5. The production function is a power function with constant returns to scale in relation to private capital and labour input:

$$y_t = e^{z_t} k_t^\alpha l_t^{1-\alpha} ,$$

where:

z_t – total factor productivity,

$\alpha \in (0,1)$.

The values of parameters were estimated on the basis of quarterly data for the Polish economy and on the basis of literature (c.f. Kydland, Prescott 1982; Bukowski et al. 2005; Grabek, Kłos, Utzig-Lenarczyk 2007; Kolasa 2008).

IMPACT OF INCREASE IN INCOME TAX

In the model the fluctuations in the economic activity are caused by stochastic disturbances related to tax rate:

$$\tau_t = (1 - \rho_\tau)\overline{\tau} + \rho_\tau \tau_{t-1} + \varepsilon_{\tau,t} \ ,$$

$$\varepsilon_{\tau,t} = N(0, \sigma_{\varepsilon,\tau}{}^2) \ , \ \rho_\tau \in (0,1) \ , \ \overline{\tau} > 0 \ .$$

The simulated model variables and the reaction of model variables to fiscal policy shock in Polish economy were generated with Dynare software (cf. e.g. Griffoli 2007). The impact on the economy of increase in income tax rate equal to standard deviation of tax rate shock ($\sigma_{\varepsilon,\tau}{}^2$) is shown in Figure 1.

Figure 1. The impulse-response functions - the effects of increase in income tax rate
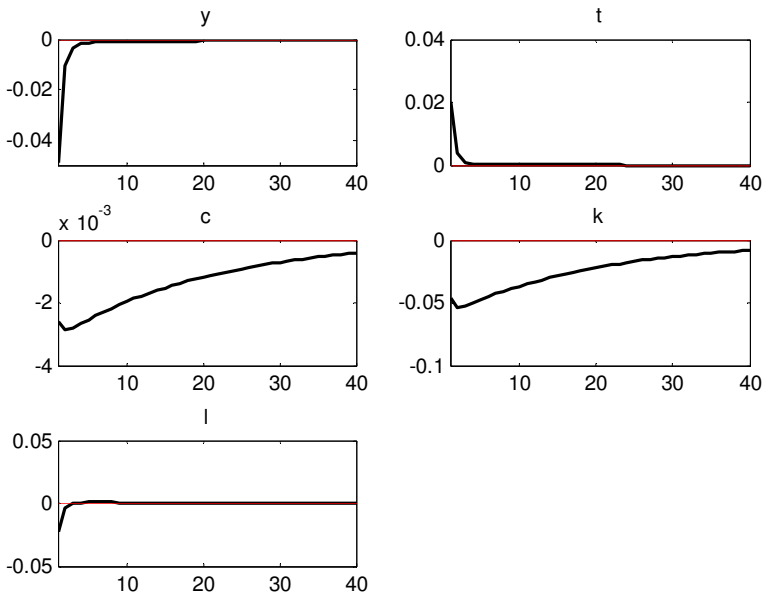
y – output, t – tax rate on income, c – consumption, k – capital, l – labour

Source: own estimation.

The increased tax rate results in decreased marginal product of capital and decreased marginal labour product after taxation. As a result, capital and employment fall, which consequently affects production. In addition, some capital is replaced by consumption, so as to prevent excessive fluctuations in

household consumption. As the tax rate returns to the baseline level, the factors of production and capital increase. At the same time, while employment returns to baseline level after just one year, the negative impact of higher taxes on capital and consumption lasts longer.

CYCLICAL CHANGES OF TAX RATES

As shown above, the model assumes that tax revenues are proportional to income, or tax rate does not depend on fluctuations in production. However, the fiscal authorities can affect the tax rate within the cycle pursuing the counter-cyclical or pro-cyclical tax policy. In the case of lower tax rates in response to increased production the fiscal policy would be of cyclical nature, while increasing the tax rates in response to decreased production would result in increased economic fluctuations[1].

In order to analyse the impact of cyclical tax rates on the dynamics of the model it was assumed that the tax rate is defined by the equation:

$$\tau_t = (1 - \rho_\tau)\bar{\tau} + \rho_\tau \tau_{t-1} + kw_{\tau,t} y_t + \varepsilon_{\tau,t} \ , \ \ \varepsilon_{\tau,t} = N(0, \sigma_{\varepsilon,\tau}^{\ 2}).$$

If $kw_{\tau,y} > 0$, then the state pursues the counter-cyclical policy (i.e. tax changes within the cycle reduce fluctuations in production). If $kw_{\tau,y} < 0$ then the state pursues pro-cyclical policy. The $kw_{\tau,y} = 0,5$ was assumed for the fiscal counter-cyclical policy and $kw_{\tau,y} = -0,5$ for pro-cyclical policy.

It was assumed that total factor productivity is defined by the following autoregressive process:

$$z_t = (1 - \rho_z)\bar{z} + \rho_z z_{t-1} + \varepsilon_{z,t} \ ,$$

$$\varepsilon_{z,t} = N(0, \sigma_{\varepsilon,z}^{\ 2}) \ , \ \ \rho_z \in (0,1) \ , \ \bar{z} > 0,$$

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[1] The cyclicality of fiscal policy is being evaluated in this paper on the basis of the level of tax rates not on tax revenues (which automatically change with GDP fluctuations and in demand-side models act as automatic stabilizers, cf. e.g. Brunila, Buti, in 't Veld 2002, Coricelli, Ercolani 2002; Józefiak, Krajewski, Mackiewicz 2005).

The technological shock ($\varepsilon_{z,t}$) and fiscal shock ($\varepsilon_{\tau,t}$) are independent variables.

The figures below present the dynamics of the model as a result of the technological shock equal to standard deviation in the case of pursuing counter-cyclical and pro-cyclical fiscal policies.

Figure 2. The effects of a positive technological shock – the case of pro-cyclical fiscal policy
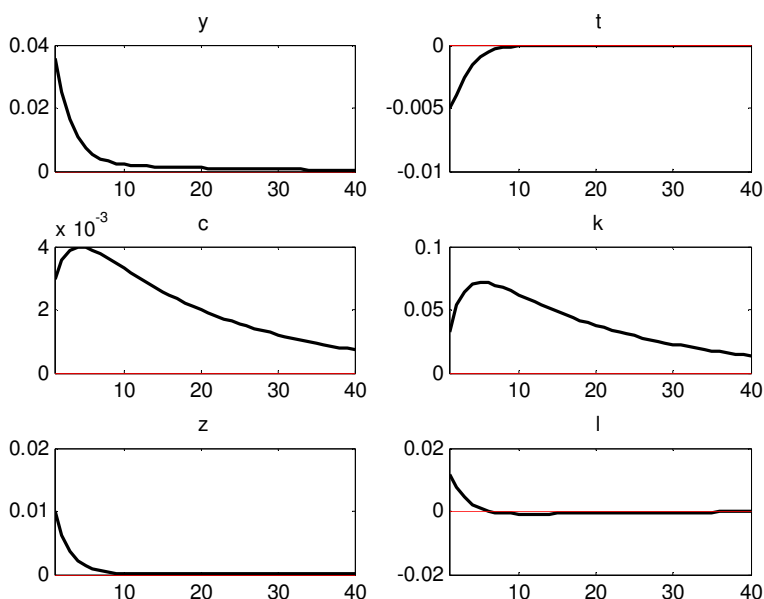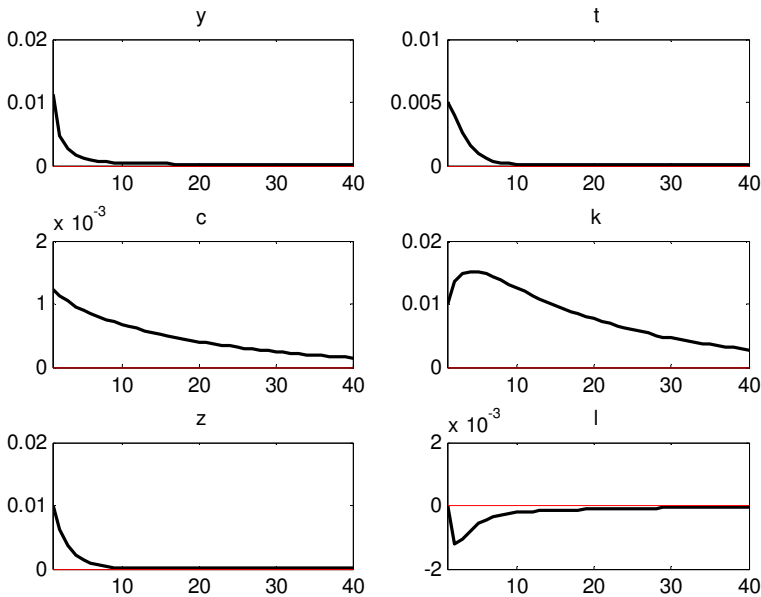

y – output, t – tax rate on income, c – consumption, k – capital, l – labour

Source: own estimation.

The impact of decline in tax rates on other variables (output, capital, consumption, and labour) is the same as in the case of a technological shock of increasing the total factor productivity. Consequently, pro-cyclical fiscal policy of lowering tax rates in response to the increase in production increases fluctuations of GDP and other variables. The counter-cyclical policy

is in this case a powerful tool smoothing fluctuations not only in production, but also in consumption, employment, and the amount of capital[2].

Figure 3. The effects of a positive technological shock – the case of counter-cyclical fiscal policy

y – output, t – tax rate on income, c – consumption, k – capital, l – labour

Source: own estimation.

The model demonstrates that tax policy to a greater extent affects the development of employment than the level of capital. As a result, with a sufficiently strong counter-cyclical fiscal policy the changes in total factor productivity and employment may run in opposite directions. Figure 3 demonstrates the case of the positive technological shock. In this case, the increase in production resulting from technological shock increases tax rates which so strongly affect the level of employment that the latter declines along with positive technological shock.

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[2] Counter-cyclical policy involving changes in government spending within the cycle leads to increased fluctuations in consumption and capital.

THE EFFECTS OF LABOUR
AND CAPITAL TAXES

It was assumed in the analysis shown in the previous section that there was only one single tax rate in the economy. In reality, the tax rates may differ for particular production factors, additionally the taxes imposed on consumption play a very important fiscal role. At the same time the strength and direction of the impact of changes in tax rates depend on which type of tax they concern. Therefore, the impact of changes in tax rates on production and other variables in the model was analyzed separately for specific taxes.

The model was extended with the following types of taxes:

– tax on wages,
– tax on income from capital,
– consumption tax.

State budget constraint is defined in this case by the equation:

$$
\sum_{t=1}^{\infty} \frac{g_t + Tr_t}{\prod\limits_{j=1}^{t}\left(1+(1-\tau_{k,j})r_j\right)} =
$$
$$
= \sum_{t=1}^{\infty} \frac{\tau_{w,t}w_t l_t + \tau_{k,t}(\rho_t - \delta)k_t + \tau_{c,t}c_t + LS_t}{\prod\limits_{j=1}^{t}\left(1+(1-\tau_{k,j})r_j\right)} \quad ,
$$

where: $\tau_{k,t}$ is a tax rate on income from capital, $\tau_{w,t}$ is a tax rate on wage income, $\tau_{c,t}$ is a tax rate on consumption, $\tau_{c,t}, \tau_{k,t}, \tau_{w,t} \in (0,1)$.

The household budget constraint is defined by the equation:

$$
\sum_{t=1}^{\infty} \frac{(1-\tau_{c,t})c_t + (1-\tau_{w,t})w_t(1-l_t)}{\prod\limits_{j=1}^{t}\left[1+(1-\tau_{k,j})r_j\right]} =
$$
$$
= k_0 + \sum_{t=1}^{\infty} \frac{(1-\tau_{k,t})w_t - LS_t + Tr_t}{\prod\limits_{j=1}^{t}\left[1+(1-\tau_{k,j})r_j\right]} \quad .
$$

The purpose of this analysis is to determine the impact of singular, one-year long (4 periods) changes in regulations on taxation of income from capital, wages, and consumption. The shocks concerning the shape of individual tax rates take the following form:

$$\tau_{k,t} = \bar{\tau}_k + \sum_{j=0}^{3} \varepsilon_{\tau k, t-j}, \quad \varepsilon_{\tau k, t} = N(0, \sigma_{\varepsilon, \tau k}^2) \ ,$$

$$\tau_{w,t} = \bar{\tau}_w + \sum_{j=0}^{3} \varepsilon_{\tau w, t-j}, \quad \varepsilon_{\tau w, t} = N(0, \sigma_{\varepsilon, \tau w}^2) \ ,$$

$$\tau_{c,t} = \bar{\tau}_c + \sum_{j=0}^{3} \varepsilon_{\tau c, t-j}, \quad \varepsilon_{\tau c, t} = N(0, \sigma_{\varepsilon, \tau c}^2) \ .$$

where $\bar{\tau}_k$, $\bar{\tau}_w$, $\bar{\tau}_c$ represent average rate of taxation of capital, labour, and consumption respectively.

Other assumptions are the same as in the case of a model in which there was only one rate of income taxation.

The impact of the 4 quarters-lasting increase (by 1 percentage point) in taxation of income from capital and labour is shown in the following charts.

As shown in Figure 4, the increase in capital taxation reduces the level of capital and employment, and consequently lowers the level of production. At the same time consumption is increasing, because during the period of higher taxation of capital, households substitute part of the capital which brings lower after-tax income over this period, with consumption. As a result, investments are decreasing and consumption increases. After the period when tax rate returns to the initial level, capital is gradually restored and consumption is gradually increasing, but for many periods remains below the level before the shock.
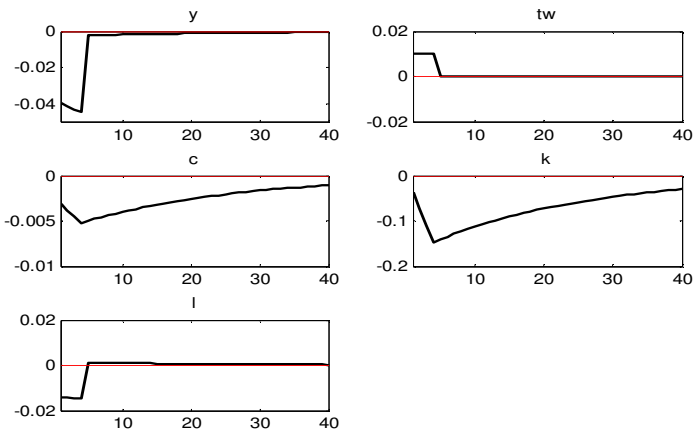
Figure 4. The effects of increased capital tax
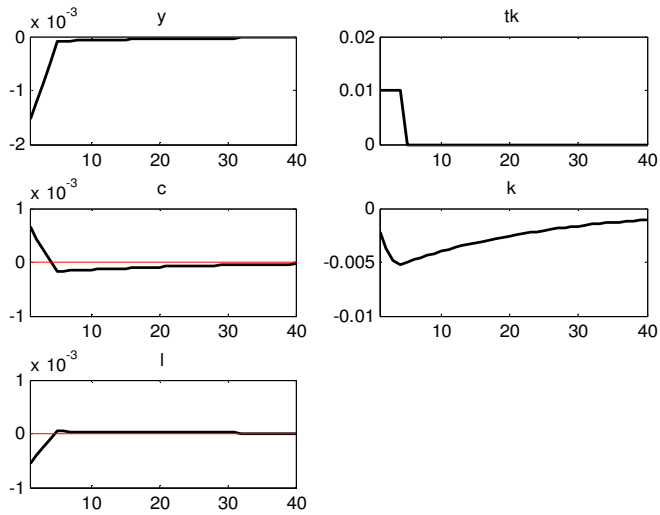
y – output, tk – tax rate on capital income, c – consumption, k – capital, l – labour

Source: own estimation.

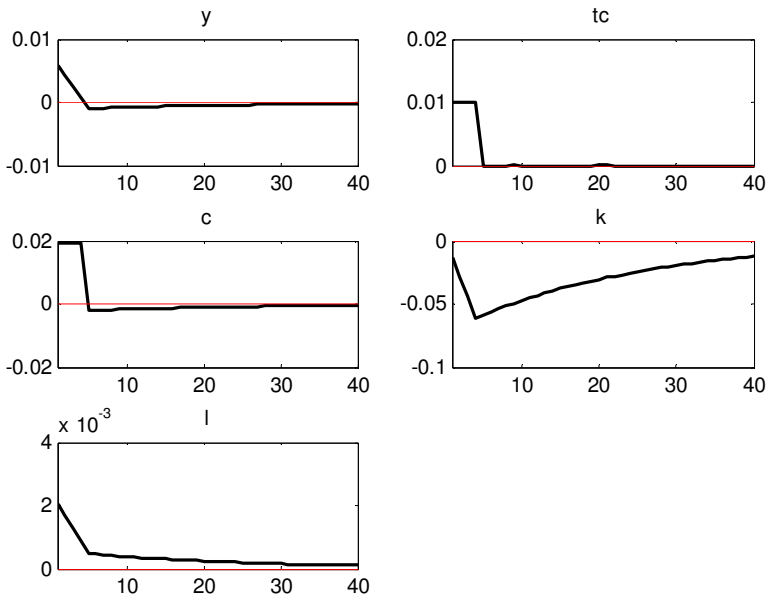**Figure 5**. The effects of increased labour tax

y – output, tw – tax rate on wages, c – consumption, k – capital, l – labour

Source: own estimation.

In the case of increased tax on labour income, the employment declines because the after tax marginal product of labour has been reduced. The amount of capital has also been reduced because on the one hand, with lower level of employment, the marginal product of capital declines and on the other hand, the capital is converted into consumption in order to minimize fluctuations in consumption.

Comparing the changes in the taxation of income from capital and labour, it can be observed that the change in wage taxation affects the economy stronger in terms of supply than the change in taxation of capital. In the case of increased taxes levied on wages, the output, employment, and the level of capital are further reduced.

Figure 6. The effects of increased consumption tax

y – output, tc – tax rate on consumption, c – consumption, k – capital, l – labour

Source: own estimation.

Figure 6 shows the effects of increased tax levied on consumption. The effect of increased tax rate is, in this case, similar to the effects of increase in government spending because the negative wealth effect takes place and while consumption before taxation grows, it declines after taxation. Addi-

tionally, employment grows and the amount of capital decreases (in order to smooth consumption fluctuations).

The impact of transitional increase in employment on output is stronger than the supply effect of the reduced level of capital. Consequently, the analyzed model shows that the increased tax on consumption results in transitional increase in production, contrary to results obtained in demand models.

CONCLUSIONS

The purpose of the paper was to analyze the impact of tax rate changes on main macroeconomic variables in the Polish economy.

The simulations based on DSGE model confirm the hypothesis that the increased tax rates adversely affect GDP. The model shows that the increase in tax rate is followed by the reduced level of capital and employment and consequently by the reduced output. In addition, part of capital is replaced by consumption, so as to prevent excessive fluctuations in household consumption. While employment returns to baseline level after just one year, the negative effect of higher taxes on the amount of capital and consumption is longer lasting. The hypothesis was confirmed that changes in income taxes have stronger effect on capital than on employment.

It follows from the model that counter-cyclical fiscal policy of increased tax rates in response to the increase in production is a powerful tool to reduce not only fluctuations in production, but also in consumption, employment, and in the amount of capital. It should be noted that since fiscal policy affects the level of employment to a greater extent than the level of capital, therefore, with a strong counter-cyclical fiscal response to a positive technological shock, along with increasing GDP, the level of employment may decline.

The paper also presents the supply-side effects of changes in tax rates classified into various types of taxes, i.e. taxes on wages, income from capital, and consumption. Comparing the changes in the taxation of income from capital and labour, it can be observed that a change in wage tax has a stronger supply side impact on economy than the change in taxation of income from capital. Therefore, the hypothesis that taxation of income from capital has a stronger impact on GDP than taxation of labour was not confirmed.

When taxes on wages increase, the output, employment, and what is especially interesting, the level of capital are strongly reduced. On the other hand, the increased consumption tax affects the economy through negative wealth effect. Consequently, due to increased taxation of consumption employment increases and the amount of capital decreases. The impact of the temporary increase in employment in production in this case is stronger than

the supply side effect of reducing the level of capital and consequently, the model shows that the increase in consumption tax is followed by a temporary increase in production. The impact on production is in this case different than it follows from demand-side models

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