Danmarks Statistik
MODELGRUPPEN

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Collecting inspiration to develop a fiscal reaction rule for ADAM

Resumé:

This paper aims to investigate the applicability of various fiscal policy rules for ADAM. We conduct a preliminary analysis on the effect of both back-ward and forward-looking fiscal policy rules in ADAM.

Dea

Keywords: fiscal reaction function, debt sustainability, tax rate

1. Introduction

Fiscal policy rules are employed in various macroeconomic models. One typical approach to formulate a fiscal policy rule is to model the tax rate to respond for any deviations in debt ratio from its target value. One may also let the tax rate error-correct the deficit ratio, perhaps the primary deficit, to keep the deficit on its target value. In both cases, the intertemporal government budget constraint should be satisfied and the debt ratio should converge to its target which may be its value in the baseline scenario before the shock. Thus, the fiscal policy rule ensures the fiscal sustainability against any shock in the model.

The Danish Annual Aggregate Model (ADAM) does not have a fiscal reaction rule that rules out Ponzi games and debt explosion in the long-run. Without going into details, this paper illustrates and comments on the effect of applying a few commonly used fiscal policy rules in ADAM.

1. Debt arithmetic in ADAMs standard baseline

Before we proceed to the simulation analysis, we would like to note a point that is worth mentioning. In a baseline for ADAM, the nominal interest rate and nominal growth rate are normally equal. If the two rates are equal, the long-run steady state of the public debt ratio is undefined for a given tax rate; i.e. the debt ratio is not a function of the tax rate. This can be shown using the government budget constraint represented by the following relation:

$$B_t - B_{t-1} = G_t - T_t + i\,B_{t-1} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1.1)$$

The change in public debt (B stands for bonds) is equal to primary deficit ($G_t - T_t = P_t$) plus cost of debt servicing at the nominal interest rate ($i\,B_{t-1}$). At steady state stock and flow variables increase at nominal growth rate n. Denoting the variables in (1.1) as a ratio of GDP (Y) and using $Y_t = (1+n)\,Y_{t-1}$, equation (1.1) becomes:

$$b_t = \frac{1+i}{1+n}\,b_{t-1} + p_t \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1.2)$$

If we have a steady state with both debt and primary deficit at target relative to GDP, $b_t = b_{t-1} = b^*$ and $p_t = p^*$. Consequently, the target ratio b^* can be written as

$$b^* = \frac{1+n}{n-i}p^* \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1.3)$$

Under the dynamic efficiency condition i is larger than the growth rate n, so in this case and whenever $i \neq n$ there will be a one-to-one relation between b^* and p^* described by equation (1.3). On the other hand, if $i = n$ we cannot write (1.3). We will have to stick to (1.2) from which any steady state debt ratio, i.e. $b_t = b_{t-1}$, will disappear. Thus, the steady state debt ratio will be undefined if $i = n$ and the primary budget target p^* will be zero. Whenever $i \neq n$, the necessary steady state primary deficit p^*can be calculated from (1.3) given the desired debt ratio. And the necessary tax rate is the tax rate that makes the primary deficit equal to p^*in steady state. For $i = n$, the necessary

tax rate is always the tax rate that makes the primary deficit equal to 0 in steady state.

Consequently, For $i = n$ the solution for b_t is path dependent and all direct or indirect shocks to the public budget, e.g. from the business cycles that ADAM generates on its way to steady state, will remain in the debt ratio. In other words, the debt ratio is a hysteresis variable for $i = n$. In ADAM baselines it is standard to assume $i = n$. Hence, the permanent change in the tax rate suggested by a fiscal reaction rule will only by chance bring back the debt ratio to its initial baseline but the permanent change should always bring back the primary deficit to its baseline, which is very close to zero in a standard ADAM. A primary deficit of zero will stabilize the debt ratio and thereby make the basic fiscal assumptions sustainable. These features have to be taken into account when formulating a fiscal reaction function for ADAM.

2. Tax funding of public purchase of goods and services

Since ADAM has no fiscal policy rule, the public debt ratio is free to explode if e.g. government spending is raised. This reflects that ADAM does not need a transversality rule to be solved. As demonstrated in the ADAM book, section 11.1.6 p. 219-222, a policy maker can stabilize the public debt ratio in the long-run following a permanent increase in public purchases by raising the necessary government revenue through higher tax rates on income. A permanent increase in tax rates ensures a constant public debt ratio, and a supplementing one-off temporary tax increase eventually brings the public debt ratio back to its baseline values as demonstrated in the ADAM book. Both tax changes are calculated in a trial and error approach. The need for a temporary tax change reflects the arithmetic in the standard baseline where the level of the debt ratio is not a function of the tax rate. When the government debt ratio is stabilized the government budget constitutes a constant GDP share, and when the debt ratio is back to baseline so is the government budget as a share of GDP.

All simulation analyses in this paper are based on a relative increase in public purchase of goods and services equal to 0.06 percent real of GDP, corresponding to 1000 million kroner in the first year, i.e. 2015. The figures below show the macroeconomic effect when tax funding the extra public purchase. The simulations use *lang100* databank and *jun14* ADAM model.

The effect of tax financed permanent increase in public purchase on public debt ratio, government budget balance, primary deficit and employment:

Figure 1a *Figure 1b*

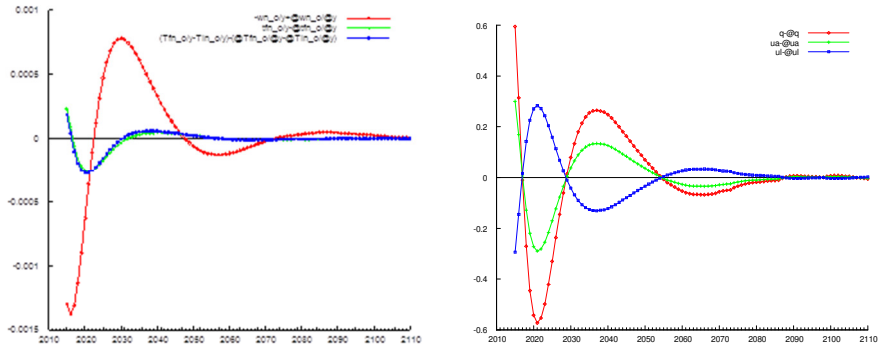


Figure 1a illustrates the effect on debt ratio (-Wn_o/y), government budget balance (Tfn_o/y) and primary surplus (Tfn_o/y-Tin_o/y). The extra public purchases of goods and services are financed by a 1.2855% permanent increase in income tax rates and 40% temporary increase in capital tax. This makes it a balanced budget multiplier experiment. Both the public debt and budget stabilize as share of GDP in the long run, so there is no long-term effect on either debt or budget.

Figure 1b shows the overall effect of tax financed public purchase. In the beginning, the expansionary effect of additional real expenditures outweighs the contractionary fiscal policy effect of higher taxes. Thus, employment rises and unemployment decline. Thereafter, employment starts to decline and unemployment begins to rise due to the decline in private consumption. The labor market variables eventually attain their equilibrium after decades of fluctuations.

The tax-financed public purchase experiment demonstrates how a policy maker can make public finances sustainable. Without a fiscal reaction function in the model, it is always the responsibility of the model user to set up and impose an appropriate fiscal policy. A fiscal reaction function could make things easier and introduce a standard for balanced budget multipliers. In the following sections, we will list a few possible tax rules for ADAM.

3. The Tax difference rule

Michell et. al. (2000) compares several fiscal policy rules. One of the rules discussed in Michell et. al. (2000) is the so-called tax difference rule, which is employed in the public version of the IMF's MULTIMOD model. This rule can be written as,

$$\Delta tr_t = \alpha(b_{t-1} - b^*_{t-1}) + \beta\Delta(b_{t-1} - b^*_{t-1}) \dots\dots\dots\dots\dots\dots\dots\dots (1.4)$$

Where Δ is the first difference operator, in MULTIMOD tr_t is the average income tax rate in the model, b^* is the exogenous target for the actual debt/GDP ratio b. α and β are constant parameters chosen by the modeler to

ensure the return of government debt ratio to its target value in the long-run. The parameter values used in MULTIMOD are $\alpha = 0.04$ and $\beta = 0.3$.

The tax difference rule error corrects the tax rate, which increases at time t if the actual debt ratio deviates from its target at time $t-1$. The tax rate is also raised if the first differences of the actual and desired debt ratios deviate at time $t-1$.

We have applied the tax difference rule in ADAM with various α and β values and using the two basic central government income tax rates tsysp1 and tsysp2 as instruments. More specifically, we replace tr in (1.4) by tsysp1 and set tsysp2 to be proportional to tsysp1. In smaller and more theoretical models, one would normally use a broad macro tax rate but we use specific rates in ADAM. The best result seems to come when $\alpha = 0.0036$ and $\beta = 0.124$. In the multiplier experiment, the tax rate is raised gradually for a number of years, cf. *figure 2a.* The tax rate overshoots temporarily but in the long run the tax rate seems to stabilize and so does the impact on the public debt ratio. From a practical policy point of view, it is not optimal to adjust the tax rate for that many years. Besides, with this fiscal policy rule, the debt ratio is not perfectly stabilized, see figure 2b.

Figure 2: Permanent increase in government purchase, tax difference rule

Figure 2a

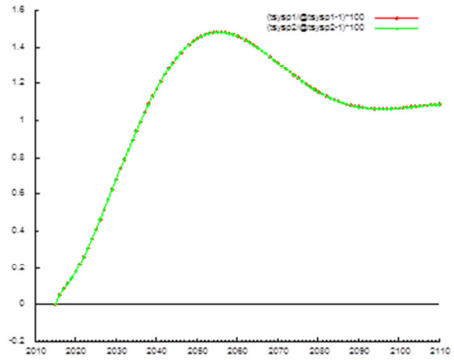


Figure 2b

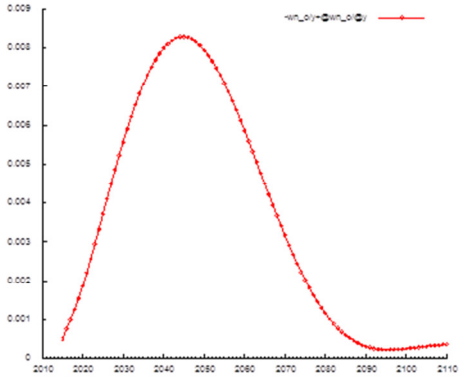


Figure 2c

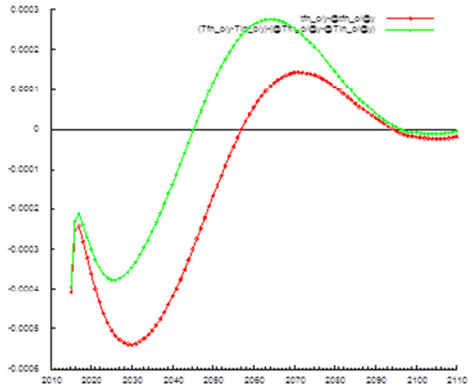


Figure 2d

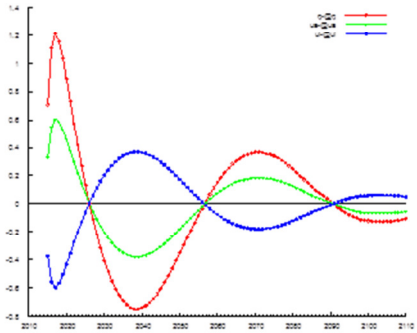


Figure 2c reports in percentage of GDP the deviation in government budget and primary surplus. Both budget and primary surplus cycle for a long period. However, the income tax rise eventually picks up the budget and makes it relatively stable. It should also be noted that the tax-financed public spending produces prolonged oscillations in the labor market, cf. figure 2d.

4. Forward-looking fiscal reaction functions

4.1 Targeting the debt ratio

Numerous fiscal reaction functions, like the one in equation (1.4), are backward-looking functions which makes the tax rate react to past deviations of the debt (or deficit) ratio from its target value. This behavior tends to make fiscal policy pro-cyclical. Instead, the fiscal policy maker may use the model to look forward and set the tax rate with a view to the long run playing down the impact of the contemporaneous and lagged budget situation. If the fiscal rule is formulated on the basis of forward looking expectations the problems of pro cyclicality might be reduced and we might obtain a smoother simulation path for say the unemployment and other key variables.

One version of IMF's MULTIMOD fiscal rule is presented below. Here, the fiscal policy maker is assumed to be both backward and forward looking and assume a target debt ratio.

$$tr_t = \sum_{i=t-2}^{i=t+2} \frac{(tr_i)}{5} + \gamma(b_{t-1} - b^*_{t-1}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1.5)$$

Where tr_t is the tax rate at time t, b^*_t is the target for the debt ratio b_t and γ is a constant parameter. The contemporaneous tax rate is a function of the average I lagged and leaded tax rates and of the deviation in the public debt ratio from its target. In (1.5) the average tax rate in year t is a sum over the tax rates from 2 years before till 2 years after divided by 5. In this way the fiscal rule incorporates both forward and backward looking expectations. This should help us to get a smooth tax rate over the simulation period.

However, the suggested rule failed to stabilize public finances and created long-lasting fluctuations in the labour market, cf. figure 3a-3d, although up to 15 leads were employed for the simulation experiments.

Figure 3. Permanent increase in government purchase, forward-looking debt rule

Figure 3a

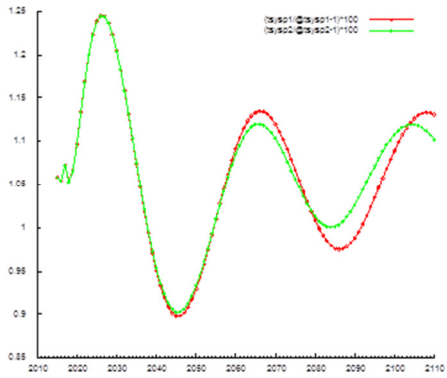


Figure 3b

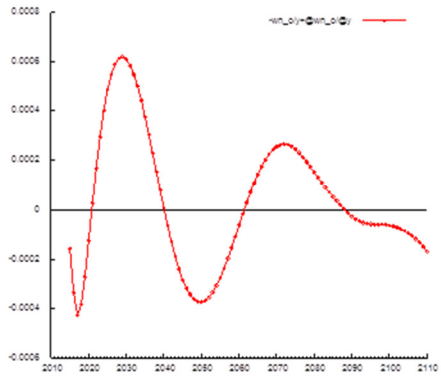


Figure 3c

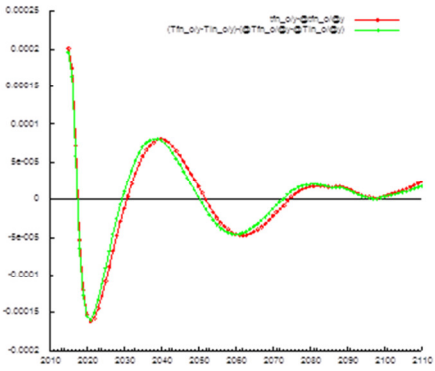
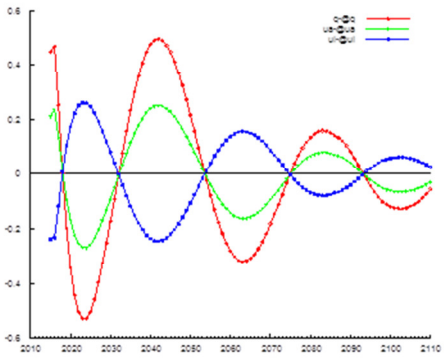


Figure 3d



As already mentioned in section 2, it might be a problem to stabilize the debt ratio because the interest rate is equal to the growth rate in the baseline applied. When the two rates are equal it is particularly difficult to control the debt ratio with the tax rate because a mixture of temporary and permanent tax changes is necessary.

Consequently, we turn to targeting the primary deficit, which should always be zero in steady state where the public debt will grow by the public interest expenditures as the interest rate is equal to the growth rate. This will only by chance restore the debt ratio to its baseline value, but the new debt ratio will be stable and thus the calculated fiscal policy will be sustainable.

4.2 Targeting the primary deficit ratio

Now, we replace the debt ratio $(-wn\_o/y)$ in equation (1.5) by the primary deficit ratio $(Tfn\_o/y - Tin\_o/y)$ so that the tax rate responds to deviations in primary deficit ratio from its steady state. If d_t and d_t^* are the actual and the target primary deficit ratios, the fiscal reaction rule in (1.5) can be rewritten as:

$$tr_t = \sum_{i=t-2}^{i=t+5} \frac{(tr_i)}{8} + \gamma(d_{t-1} - d_{t-1}^*) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1.6)$$

We now use 5 leads instead of the 2 in (1.5). In (1.6) 2 lags and 5 leads are used to calculate the average tax rate.

Moreover, we modify the original wage equation so that the wage rate error corrects at time t when the actual wage rate at $t-1$ deviates from the steady state wage rate. This wage equation is written:

$$\Delta w = 0.5 * [0.3\Delta p - 0.55(bul_{-1} - bul^{*}) + 0.029] - 0.5 * [w_{-1} - w^{*}]$$

The modification of the wage equation is taken from 'Tilpasningsrapporten' from 2013 and it should reduce the pro-cyclicality problems of the previous simulation experiments.

Figure 4 presents the effect of an increase in general government purchase and with fiscal rule (1.6) and the modified wage equation inserted in ADAM. The two applied tax rates tsysp1 and tsysp2 increase to a new steady state value relative to the baseline scenario. However, before doing that the tax rates fluctuate according to figure 4a. This seems to suggest that the fiscal rule is still far from ideal. An ideal fiscal reaction rule should generate a tax rate that quickly and smoothly attains its new equilibrium level.

Figure 4b and 4c reports the effect on the public finances and the debt ratio looks more stable than in the previous experiments. We note a long-term increase in the debt ratio in 4b, a long-term deterioration in the budget and a long-term zero effect on the primary budget. Moreover, the effect on the labour market seems to stabilize after some 50 years close to the expected zero effect on unemployment. That is per se an encouraging outcome, but we have augmented the wage equation with forward-looking expectations so it is not an optimal solution.

Figure 4. Permanent increase in government purchase, forward-looking primary deficit rule

Figure 4a ***Figure 4b***

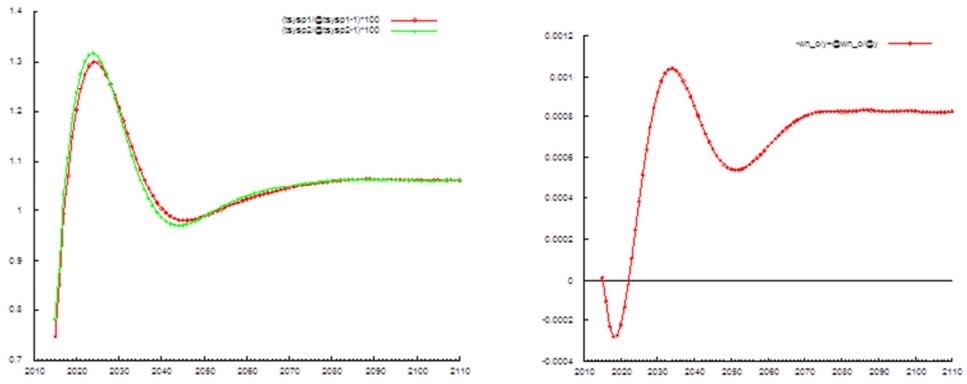


Figure 4c

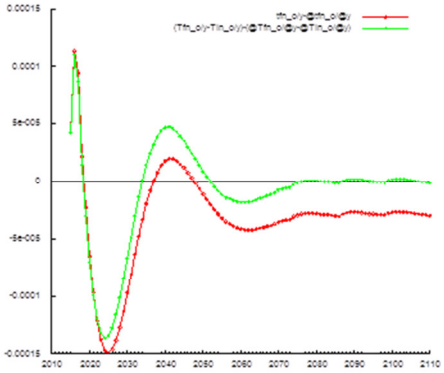
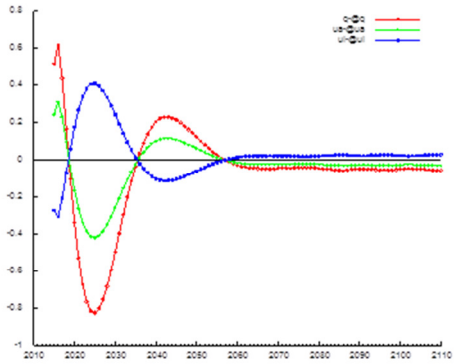


Figure 4d



4.3 Explicit model-based rule

Pérez & Hiebert (2002) suggest a fiscal rule that reflects the stability properties of the model instead of imposing a pre-chosen error-correcting mechanism.

They implement their idea for a small stylized macro model that can be solved analytically, and the resulting rule-based tax rate is primarily a function of the initial shock to the model. We cannot solve ADAM analytically, but almost all of the necessary tax changes suggested in Pérez & Hiebert take place in the first period, i.e. like a simple balanced multiplier where higher government expenditure is accompanied by an adequate tax increase.

In practice, this comes close to the result of the ADAM exercise in section 2 above on tax-financing a permanent expenditure increase to secure a stable public debt or budget ratio. That is, first we calculate the necessary permanent tax change by trial and error, and then we implement the full permanent tax change from year one and onwards.

5. Conclusion

This study aims to collect ideas and preliminary assess the implication of using fiscal reaction functions in ADAM. Both forward and backward looking fiscal reaction functions are tested in the model. Three conclusions can be drawn from the analysis. First, the manual searching process for the steady state tax rate, which stabilizes the debt ratio, is a possible solution but it should preferably be formalized to introduce a fiscal reaction rule in ADAM. Second, forward looking fiscal rules may be more appealing than simple backward looking models, but this point has not been proven. And third, the fiscal reaction function should be formulated with a view to the standard baseline assumption of growth equal to interest rate.

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