Fachbereich Wirtschaftswissenschaften der Universität Münster

Institut für Internationale Ökonomie

Problem Set 3

im Fach

Advanced Macroeconomics (PhD level)

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Exercise 1: Baxter and King (1993)

task 1

In regression analysis, endogenous variables are the variables which depend on the values of the independent, the exogenous variables. Therefore, the endogenous variables are determined in the model, whereas the exogenous variables are already known before making calculations.

The same idea can be found when using DSGE models: Endogenous variables like consumption C_t and output Y_t are determined by optimizing behaviour of the agents in the model (households and firms), whereas the exogenous variables, the shocks, “come from outside” and influence the decisions of the agents (and therefore the endogenous variables). Since the shocks usually follow an AR(1)-process, the variables corresponding to the growth of the shocks over time are also determined in the model (and are endogenous, too).

Under the assumption that output is produced by a Cobb-Douglas-type production function, an increase in capital K_{t-1} does not lead to an increase in output in the same amount. The model parameter α shows the elasticity of output to changes in capital. Therefore, model parameters show the relationship between the variables on the “left side” of the equation and the ones on the “right side” (or only on the “right side” (e.g. parameters show preferences)).

In the model of Baxter and King S contains all endogenous variables:

$$S = \left\{ \begin{matrix} \tau_t, w_t, C_t, N_t, K_t, I_t, K_t^B, I_t^B, Y_t, z_t, r_t, G_t^B, TR_t, dY_t, dC_t, dI_t, dN_t, dw_t, dr_t, dTR_t, dG_t^B, \\ dI_t^B, \lambda_t \end{matrix} \right\}$$

E contains all exogenous variables:

$$E = \left\{ \varepsilon_t^z, \varepsilon_t^{G^B}, \varepsilon_t^{I^B}, \varepsilon_t^\tau \right\}$$

The parameter Θ inludes all model parameters and calibrated values.

$$\Theta = \left\{ \theta_l, \beta, \delta, \alpha, \eta, \rho_z, \sigma_z^2, \rho_{G^B}, \sigma_{G^B}^2, \rho_{I^B}, \sigma_{I^B}^2, \rho_\tau, \sigma_\tau^2, \bar{G}^B, \bar{I}^B, \bar{Y}, \bar{C}, \bar{I}, \bar{N}, \bar{w}, \bar{r}, \overline{TR}, \bar{z}, \bar{\tau}, \bar{K}, \bar{K}^B \right\}$$

task 2

given information:

$\bar{Y} = 1$

$\bar{G}^B = 0.20\bar{Y} = 0.20 * 1 = 0.20$

$\bar{I}^B = 0.02\bar{Y} = 0.02 * 1 = 0.02$

$\overline{TR} = 0$

$\bar{w} = 2$

$\bar{N} = \frac{1}{3}$

$\eta < \alpha$

$\rho_z = \rho_{G^B} = \rho_{I^B} = \rho_\tau = 0.75$

$\sigma_z^2 = \sigma_{G^B}^2 = \sigma_{I^B}^2 = \sigma_\tau^2 = 0.01^2$

β is the discount factor. β should take on a value near one to avoid that the household has some time preference. Therefore I set β equal to 0.99, which is equal to an annual interest rate of around four percent $(0.99^{-1})^4$.

For δ I use the value from the paper of Baxter and King. Therefore δ is equal to 0.025, i.e. representing a realistic annual depreciation rate of ten percent of the corresponding (private or public) capital stock.

From equation (7) we can get the value for α:

$\bar{w}\bar{N} = (1 - \alpha)\bar{Y}$

$\Leftrightarrow \alpha = 1 - \frac{\bar{w}\bar{N}}{\bar{Y}} = 1 - \frac{2*\frac{1}{3}}{1} = \frac{1}{3}$

Therefore α takes on the usual value in a Cobb-Douglas production function (share of private capital in production).

Since η should be smaller than α, I set $\eta = 0.05$ (such that government capital is less productive compared to private capital). This is the value Baxter and King used in their paper. A small value makes intuitively sense since the public capital stock, e.g. the infrastructure like streets and airports, can improve logistic issues, but does not directly increase production.

Equation (5) yields the steady-state for K_t^B:

$\bar{K}^B = (1-\delta)\bar{K}^B + \bar{I}^B$

$\Leftrightarrow \bar{K}^B = \frac{\bar{I}^B}{\delta} = \frac{0.02}{0.025} = 0.80$

Since all variables are in steady-state in this exercise, I do not mention this explicitly in the following.

Then one can substitute equation (8) in equation (10):

Equation (8): $\bar{r}\bar{K} = \alpha\bar{Y}$

Equation (10): $\bar{G}^B + \bar{I}^B + \overline{TR} = \bar{\tau}(\bar{w}\bar{N} + \bar{r}\bar{K})$

$\Rightarrow \bar{G}^B + \bar{I}^B + \overline{TR} = \bar{\tau}(\bar{w}\bar{N} + \alpha\bar{Y})$

$\Leftrightarrow \bar{\tau} = \frac{\bar{G}^B + \bar{I}^B + \overline{TR}}{\bar{w}\bar{N} + \alpha\bar{Y}} = \frac{0.20+0.02+0}{2*\frac{1}{3}+\frac{1}{3}*1} = 0.22$

The value of 22 percent seems to be reasonable for an income tax, because the german GPD per capita (2014) is around 35500 € and according to the EStG you have to pay an average tax rate of around 22 % in this case (if you are a single).

Equation (2) with (3) yields the value for the interest rate (since $\bar{\lambda} = \frac{1}{\bar{C}}$):

$\frac{1}{\bar{C}} = \beta\frac{1}{\bar{C}}(1 - \delta + (1-\bar{\tau})\bar{r})$

$\Leftrightarrow \bar{r} = \frac{\frac{1}{\beta} - 1 + \delta}{(1-\bar{\tau})} = \frac{\frac{1}{0.99} - 1 + 0.025}{1-0.22} \approx 0.045$

This result validates the explanation from above (discount factor).

From equation (8) one can obtain $\bar{K}$:

$\bar{r}\bar{K} = \alpha\bar{Y}$

$\Leftrightarrow \bar{K} = \frac{\alpha\bar{Y}}{\bar{r}} = \frac{\frac{1}{3}*1}{0.045} \approx 7.4074$

Equation (4) gives the steady-state for private investments:

$\bar{K} = (1-\delta)\bar{K} + \bar{I}$

$\Leftrightarrow \bar{I} = \delta\bar{K} = 0.025 * 7.4074 \approx 0.1852$

The (private) savings rate in Germany is in reality with a value of around ten percent much smaller than this value (the reason for this can be the high interest rate in the model compared to reality) (the private savings rate is even much higher than eighteen percent (see next step ($\bar{C}$)).

Now $\bar{C}$ can be determined from equation (14):

$\bar{Y} = \bar{C} + \bar{I} + \bar{G}^B + \bar{I}^B$

$\Leftrightarrow \bar{C} = \bar{Y} - \bar{I} - \bar{G}^B - \bar{I}^B = 1 - 0.1852 - 0.20 - 0.02 = 0.5948$

Consequentially the private propensity to consume is around 76 % (since $\frac{0.5948}{0.5948+0.1852} \approx 0.7626$) and therefore smaller than in reality (90 %).

θ_l is the Frisch elasticity of labour and can be derived from equation (1):

$(1-\bar{\tau})\bar{w} = \theta_l \frac{\bar{C}}{1-\bar{N}}$

$\Leftrightarrow \theta_l = \frac{(1-\bar{\tau})\bar{w}(1-\bar{N})}{\bar{C}} = \frac{(1-0.22)*2*\left(1-\frac{1}{3}\right)}{0.5948} \approx 1.7485$

Since $\theta_l > 1$, the households react very sensitive (regarding their labour supply) to changes in wages.

From equation (3) we get the value for $\bar{\lambda}$:

$\bar{\lambda} = \frac{1}{\bar{C}} = \frac{1}{0.5948} \approx 1.6812$

From equation (6) we can get $\bar{z}$:

$\bar{Y} = \bar{z}(\bar{K}^B)^\eta \bar{K}^\alpha \bar{N}^{1-\alpha}$

$\Leftrightarrow \bar{z} = \frac{\bar{Y}}{(\bar{K}^B)^\eta \bar{K}^\alpha \bar{N}^{1-\alpha}} = \frac{1}{0.80^{0.05}*7.4047^{1/3}*(1/3)^{1-1/3}} \approx 1.0792$

$\bar{z} > 1$ indicates that the freely selectable values (e.g. η) are responsible for this result. In the steady-state technology actually should not have an effect on the production level, i.e. $\bar{z} = 1$ (but in the following I use the value larger than one).

tests for controlling results:

Equation (8):

$\bar{r}\bar{K} = 0.045 * 7.4074 \approx \frac{1}{3} * 1 = \alpha\bar{Y}$

$\bar{G}^B + \bar{I}^B + \overline{TR} = 0.20 + 0.02 + 0 \approx 0.22\left(2 * \frac{1}{3} + 0.045 * 7.4074\right) = \bar{\tau}(\bar{w}\bar{N} + \bar{r}\bar{K})$

Since all observables (equations (15) - (23)) are defined as deviations from their steady-state values, their values are zero in steady-state:

$\Rightarrow d\bar{Y} = d\bar{C} = d\bar{I} = d\bar{N} = d\bar{w} = d\bar{r} = d\overline{TR} = d\bar{G}^B = d\bar{I}^B = 0$

Equations (9), (11) - (13) are satisfied in the steady-state, because there is no shock (stochastic component) in the steady-state (i.e. $\bar{\epsilon}_t^z = \bar{\epsilon}_t^{G^B} = \bar{\epsilon}_t^{I^B} = \bar{\epsilon}_t^\tau = 0$) and $\log\left(\frac{\bar{z}}{\bar{z}}\right) = \log\left(\frac{\bar{\tau}}{\bar{\tau}}\right) = \log(1) = 0$.

task 3

The main difference between deterministic and stochastic models is that in the stochastic case model agents do not know when and in which direction/amount future shocks occur, whereas in the deterministic case agents exactly know the point in time at which the shock takes place and exactly know how the shock affects the economy. Thus the agents in the deterministic case can take the future shock(s) (completely) into account for decision making. According to this they adjust their optimization plan to furthermore pursue their objective function in an optimal way. The announcement of an increase in the sales tax is a good example, because households change their consumption path in favour of durable and/or very expensive goods before the “cost” shock affects the economy. Consequentially deterministic models can be used if an occurrence of an innovation in the future is completely certain and predictable, independent of the duration the shock takes place and thus the model gives you an impression about the influence of this shock on the economy (further examples: Abwrackprämie, introduction of a new currency, ...). In contrast to the deterministic case shocks occur unexpected in stochastic models (e.g. eruption of the financial crisis). Besides you only know (assumption) the distribution of a shock and not - as it is the case in the deterministic model - the exact value of the shock. Since most future events are uncertain (since no one can exactly predict the future) such that agents can only make probability statements about their decisions, the usage of stochastic models is more popular. Thus the agents behaviour depends on the state of the economy. The “disadvantage” of this model type is that in contrast to the deterministic models these (non-linear) models usually must be approximated to get a solution. If you use a first order Taylor expansion, agents only consider the expectation of the shock distribution. Since the expectation is equal to zero, the agents behave as if future shocks were equal to zero. Therefore their behaviour is the same as in the deterministic case (where future shocks are zero without any uncertainty). Consequentially both models yield the same results (the same is true for linear models). When using a second order Taylor expansion, the agents also consider the variance of the shocks (which is important for financial data). According to this the results are different. Thus the usage of deterministic or stochastic models depends on the purpose (e.g. data type, known event (?)) (and the model structure ((non-)linear model) is also important, but not for a decision between both model types) .

task 4

See mod-file „exercise1_task4_5“, scenario 1.

task 5

Interpretation of the task: The two shocks should be unexpected, temporary and of the same size. Unexpected means that the shock happens in period 1 such that agents cannot adjust their decisions in advance. Temporary means that the shock is not persistent/permanent (only occurs in period 1 or last some countable periods) such that the variables (here: the observables) return back to their (old) steady-state value. The term “of the same size” I interpret as follows: Since the public consumption and the public investment shock should be of the same size, you should explicitly set how the shock affects the economy (here: only in period 1). The last mentioned point speaks in favour of a deterministic simulation, but in the stochastic setting we can also specify how the shock hits the economy. The point that the shock should be unexpected speaks clearly in favour of a stochastic simulation. According to the Dynare User Guide a deterministic shock is always expected (independent of the point in time the shock takes place (e.g. also in period 1))[1]. Because of this I use a stochastic setting to determine the impulse response functions of the observables.

The following two figures show the responses of all observables due to an unexpected temporary public consumption shock (figure 1) and an unexpected temporary public investment shock (figure 2). Doing this, both shocks increase by one unit in the first period and are (expected to be) zero afterwards. The figures show the responses zero periods after the shock takes place and over a time horizon of 200 periods (see mod-file „exercise1_task4_5“, scenario 2).

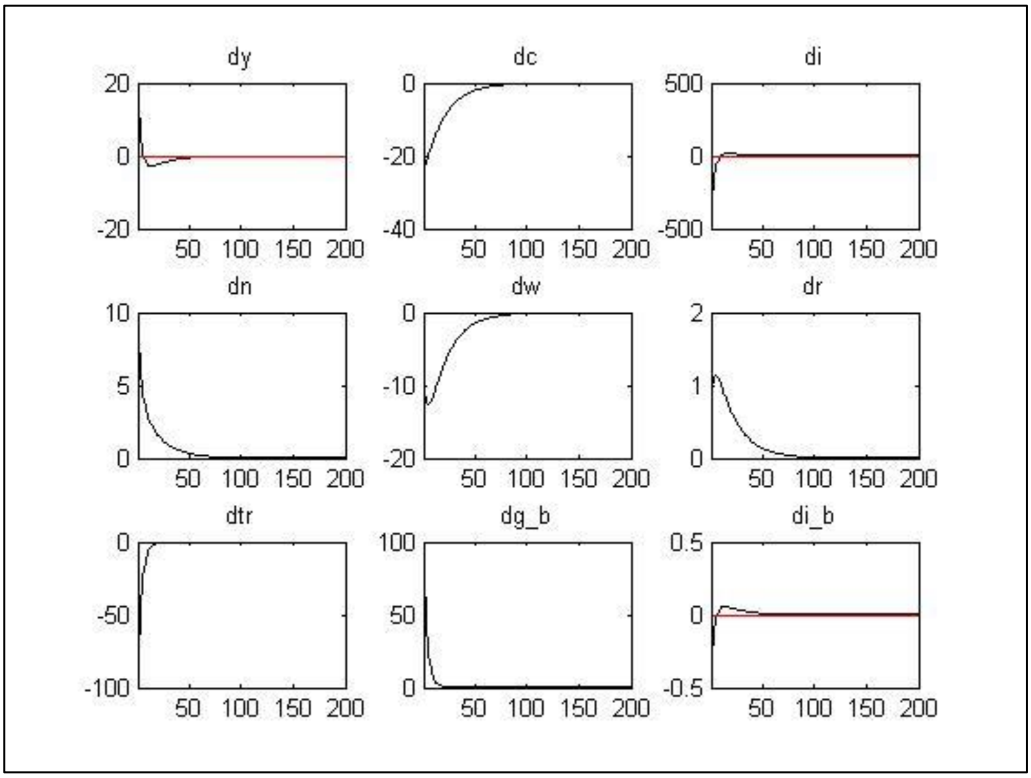

Figure 1: Responses of the observables to a temporary and unexpected public consumption shock

[1] The corresponding source is attached (pdf document “Dynare 2013”, p. 25).

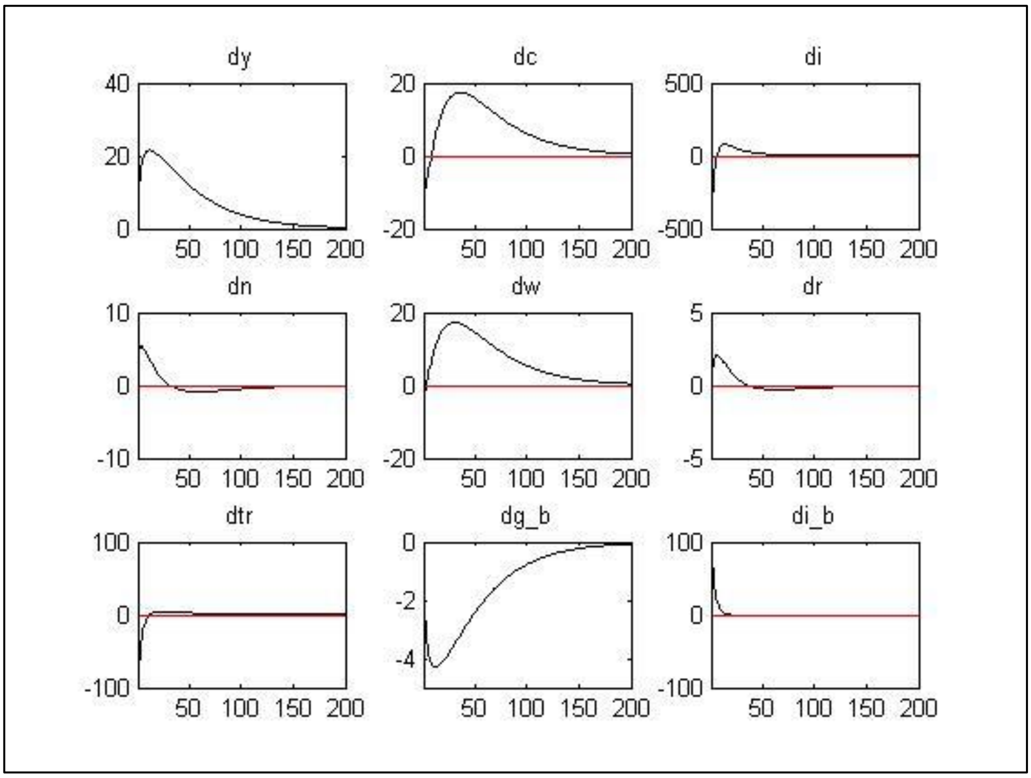

Figure 2: Responses of the observables to a temporary and unexpected public investment shock

Obviously, the observables (and therefore the real economy) are affected in both cases (since the variables deviate from their steady-state value zero). Since the shocks are not persistent, the variables return back to their steady-state value. Therefore the economy is - in the long-run - located at their base level again. In the figures above we can see that this (return) process takes a lot of time for some variables and is very short for other ones, i.e. it is variable dependent.

Since output is a very informative variable for the “real economy”, we restrict our analysis (largely) on the growth rate of the output (dy). According to figure 1 the (positive) public government shock increases output at first, but results then in a negative effect (and then converges to the steady-state). A possible reason for this can be the crowding-out effect. At first, the increased government spending increases c.p. aggregate demand and therefore output, too. Since the shock is unexpected, agents cannot adjust their decisions. But in the subsequent periods, households include the increased government spending in their decision problem. Probably they restrict their consumption spending, because they expect that they have to pay higher taxes in the future to refinance

the fiscal policy. In figure 1 we can indeed see that the households decrease consumption immediately after the (unexpected) shock takes place (dc).
This is the crowding-out effect: government spending displaces private spending.

In contrast to this the public investment shock consistently has a positive effect on dy (until dy returns back to the steady-state (as can be seen in figure 2)).
As stated above - regarding η in task 2 - a good infrastructure improves the conditions for the firms. Thus the economy benefits from public investments.

As can be seen in the next figure (3), an unexpected temporary public investment shock in combination with a higher productivity of public capital (here $\eta = 0.10 > 0.05$), leads to higher GDP growth rates in the periods after the shock takes place (see mod-file “exercise1_task4_5”, scenario 3):

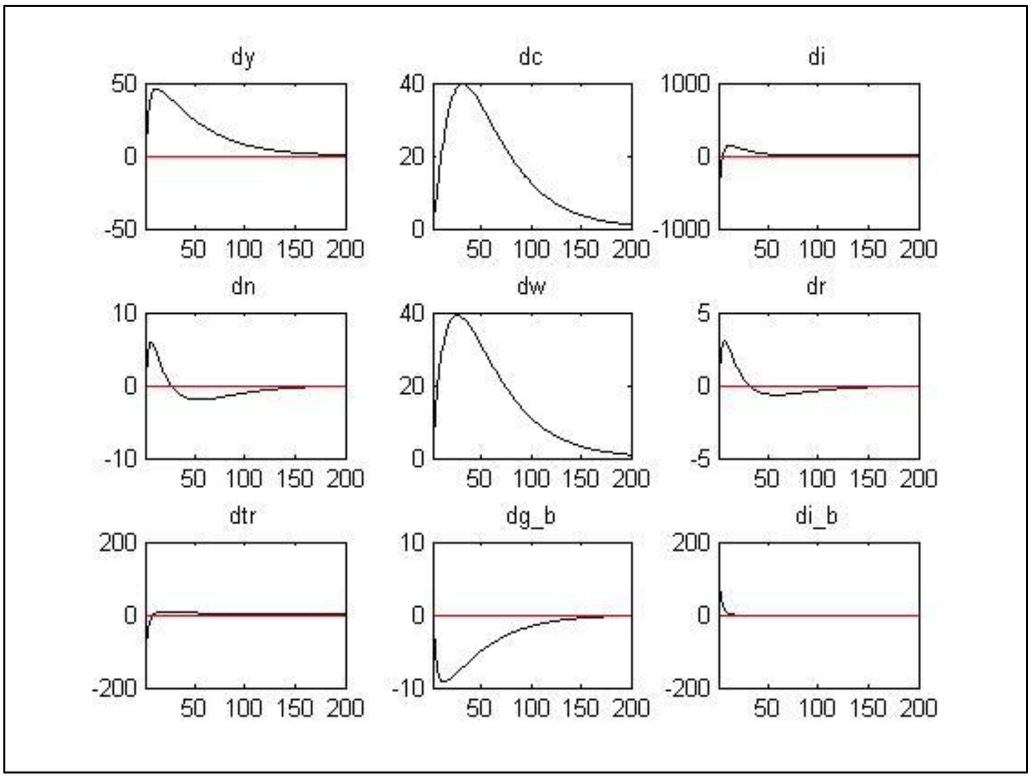

Figure 3: Observables in response to the temporary and unexpected public investment shock and higher η

The response of the observables regarding the public government shock is not affected by η:

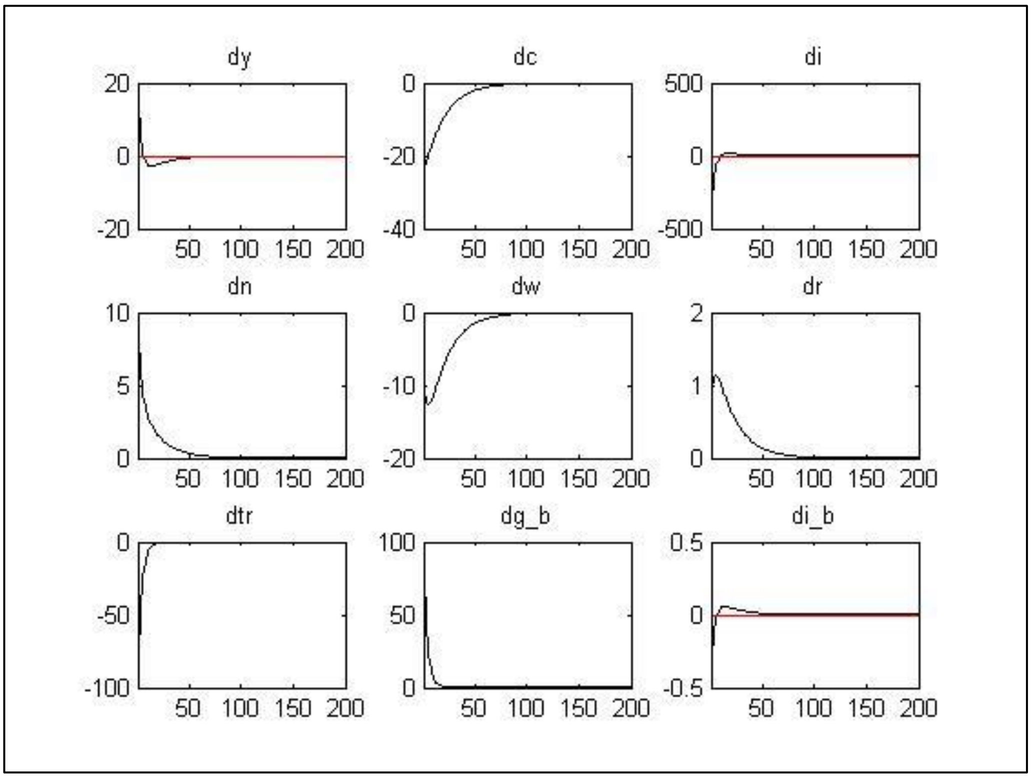

Figure 4: Observables in response to the temporary and unexpected public consumption shock and higher η

If one compares figure 2 and 4, they are exactly the same.

task 6

Interpretation of the task: Modeling of a positive and permanent tax rate shock ε_t^τ which leads to an increase in the tax rate of one percentage point, i.e. $\bar{\tau}$ increases from its old steady-state value of 22 % to its new value 23 %. And check how this affects the economy in the long-run.

Since there is not a one-to-one-relation between ε_t^τ and τ_t, an increase in ε_t^τ of 0.01 units does not increase τ_t by the same amount (equation (13): $\log\left(\frac{\tau_t}{\bar{\tau}}\right) = \rho_\tau \log\left(\frac{\tau_{t-1}}{\bar{\tau}}\right) + \varepsilon_t^\tau$). Therefore I adjust ε_t^τ such that τ_t is equal to 0.23 in its new steady-state.

Since the shock is permanent and therefore expected, I use a deterministic simulation. By the way: In reality there is also always an announcement of tax adjustments.

If you run this code in dynare, you have to keep in mind that the steady-states change. Therefore I pretend starting values to calculate the new steady-state (in dynare: initval-command instead of the steady_state_model-command using the old steady-state values as starting points (from task 2 respectively 4)). Since there is no specification about the point in time when the shock hits the economy for the first time, I assume that the shock takes place in period 1 (and is expected).

The following table compares the old with the new steady-state values (after 300 periods) (mod-file "exercise1_task6"):

	new steady-state	relation	old steady-state
$\bar{\tau}$	0.23	>	0.22
$\bar{w}$	1.9871	<	2
$\bar{C}$	0.5857	<	0.5948
$\bar{N}$	0.3308	<	$1/3$
$\bar{K}$	7.2091	<	7.4072
$\bar{I}$	0.1802	<	0.1852
$\bar{K}^B$	0.80	=	0.80
$\bar{I}^B$	0.02	=	0.02
$\bar{Y}$	0.9859	<	1
$\bar{z}$	1.07905	=	1.07905
$\bar{r}$	0.0456	>	0.0450
$\bar{G}^B$	0.20	=	0.20
$\overline{TR}$	0.0068	>	0
$d\bar{Y}$	-1.4102	<	0
$d\bar{C}$	-1.5383	<	0
$d\bar{I}$	-2.6742	<	0
$d\bar{N}$	-0.2574	<	0
$d\bar{w}$	-0.6431	<	0
$d\bar{r}$	0.0584	>	0
$d\overline{TR}$	0.6757	>	0

$d\bar{G}^B$	0.2861	>	0
$d\bar{I}^B$	0.0286	>	0
$\bar{\lambda}$	1.7075	>	1.6812

Table 1: Comparison of old and new steady-state values

Since the households loose part of their income because of the tax increase, they restrict their consumption (0.5857<0.5948) and investment (0.1802<0.1852) spending. Consequentially the capital stock is also lower (7.2091<7.4072). Since the government is not an optimizer, it does not increase its spending behaviour such that the steady-state values remain constant. Although the government transfers money to the households (0.0068>0) such that they are at least partly compensated for the increase in the tax rate (for spending purposes), output decreases (0.9859<1). (Only) Because of the smaller value of $\bar{Y}$ in the new steady-state, $d\bar{G}^B$ and $d\bar{I}^B$ take on larger values than/differ from zero. Besides the tax rate decreases the real wage (1.9871<2) so that households loose incentive to work and therefore reduce labour (0.3308<$1/3$). The long-run Lagrange-multiplier also increases, because the income of the household decreases because of the tax rate increase and therefore the household has to consider the budget constraint more intensively in the optimization problem (implying a larger value of $\bar{\lambda}$). Technology $\bar{z}$ is unaffected by changes in the tax rate.

The following figure shows the transition path from the old to the new steady-state for output. Although the shock is expected, the largest changes occur in the periods immediately after the shock takes place. This response behaviour is the same for all variables (which change). Therefore I renounce to show the figures for the other variables (see mod-file "exercise1_task6" for the other figures).

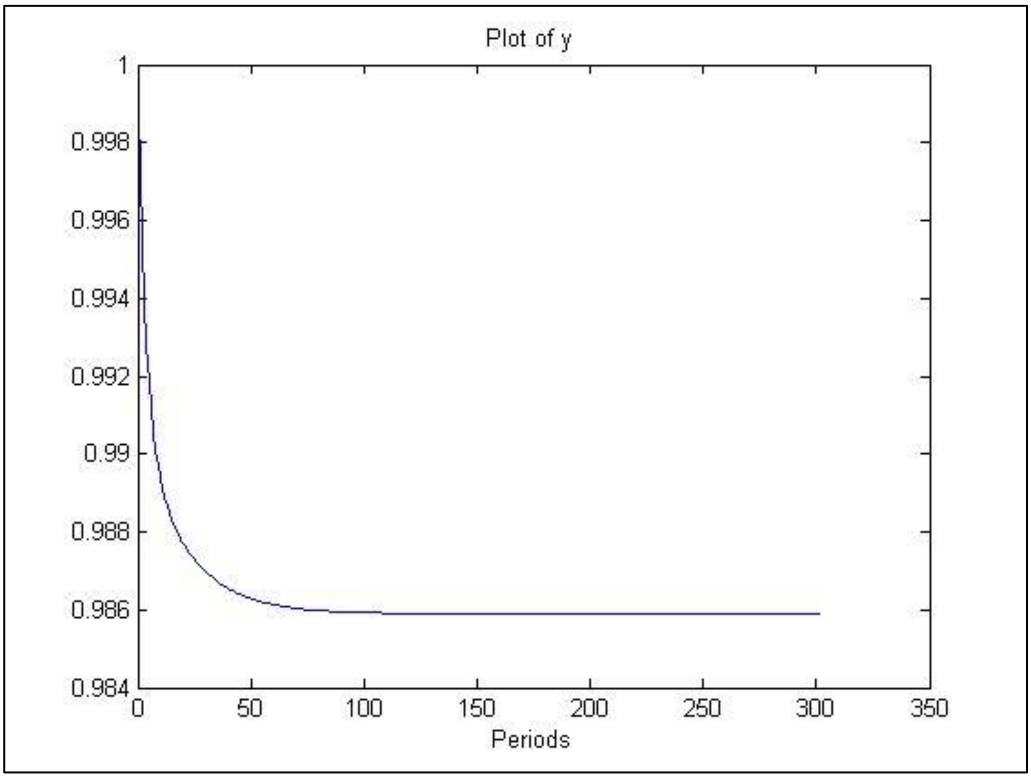

Figure 5: y in response to the permanent increase in the tax rate

task 7

As stated above (in task 5, figure 1), a temporary and unexpected public consumption shock can only boost the economy immediately after the shock takes place. The reason for this is that the shock occurs unexpected. But in the subsequent periods the agents consider expectations in their optimization problem (like the expected tax rate $E_t\tau_{t+1}$ (equation (2))). Therefore they could think that they have to pay higher taxes in the future to refinance the (actual increase in the) government spending. These expectations influence their actual decisions. In figure 1 (dc) we have seen that the households indeed reduce consumption in response to the (expansive) fiscal policy (and investments (di) for a very short time, too). Therefore the (temporary) fiscal policy has only a positive effect on output in the short-run. In the long-run output remain on its base level. Because of the displacement of private spending output returns back very quickly to its steady-state value (another reason for this is the mild persistence parameter ρ_{G^B} of 0.75).

In task 6 we have seen that a permanent increase in the tax rate reduces output. Although there is no direct connection between task 5 and 6, it is not erroneous to believe that the temporary fiscal policy (in task 5) is refinanced by the permanent increase in the tax rate (in task 6). But this example shows again that output does not increase in response to (temporary expansionary) fiscal policy. In task 6 consumption (and investments) also decrease in response to the tax rate shock.

Therefore I do agree with Willi that fiscal policy cannot boost the economy due to the implied crowding-out of private consumption and investment.

As stated above (task 2), government capital represents logistic issues like streets and airports (infrastructure). But the government capital also include components like the supply of water, gas, electricity, … and the imparting of (general) education (e.g. through school). One can conclude that government capital comprises the general conditions for firms. But these things do not automatically produce something. For this, firms need private capital. This does not only include money, but above all special machines and specific knowledge (human capital) in the business where the firm is active.

A dentist is a good example for illustration: A dentist has specific abilities and needs specific machines and tools, but the dentist also needs cleaned water for working.

Consequentially firms need both capital sources, but private capital is much more important such that the parameter for η is much smaller than the ones for the other input factors.

Exercise 2: An and Schorfheide (2007)

task 1

In regression analysis you need at least as many instruments as you have endogenous variables when using the instrument variable approach. Otherwise you have not got enough information to infer the causal effect. In estimating DSGE models via Bayesian techniques the idea is similar, because there you need one observable variable for each shock to prevent singularity problems. Since An and Schorfheide consider three shocks in their model $(\epsilon_{R,t}, \epsilon_{g,t}, \epsilon_{z,t})$, you need to include three observables, too. An and Schorfheide include the quarter-to-quarter per capita GDP growth rates (YGR), the annualized quarter-to-quarter inflation rates (INFL) and the annualized nominal interest rates (INT). The defined measurement equations for the observables connect the (real) data with the model parameters.

Dynare-command: varobs YGR INFL INT;

Mod-file: exercise2

task 2

See mod-file "exercise2", section "task 2".

Data for YGR, INFL, and INT is generated via the stoch_simul-command (10000 observations).

task 3

Bayesian estimation techniques combine two approaches: the maximum-likelihood method, which chooses the (model) parameters in such a way that the likelihood of getting the observables of the known sample again, is maximized. And the calibration method, which chooses the parameters according to the values known from literature. Consequentially the Bayesian approach is on the one hand based on data (maximum-likelihood) and on the other hand based on prior knowledge (calibration method). The calibration method is nevertheless an estimation approach, too, because the resulting values stem from studies in which the parameters are especially estimated. Since studies usually differ in results, the "knowledge" for each parameter is considered as a distribution in the Bayesian approach. This is exactly the reason why it is essential to use Bayesian techniques: Maximum-likelihood only delivers one parameter value, but you do not know, how confident you can be in that estimated value. Besides the data usually does not contain enough information to get a "good", realistic parameter value. This can lead to absurd parameter values and therefore biased results. The inclusion of prior information can strongly improve the estimated values for the parameters (in the sense that the resulting values seem to be more realistic, e.g. if the estimated capital share α in production (exercise 1) is 0.01 or 0.95, no one would believe in policy proposals derived from these estimations). The influence of prior information in Bayesian estimation results decreases, the larger the sample size is (in the limit Bayesian results converge to the ones you would get from a maximum-likelihood estimation).

task 4

The model is estimated with the given code of the exercise sheet.
See mod-file "exercise2", section "task 4".

task 5

The following two figures show the graphs you get from executing the estimation command in task 4:

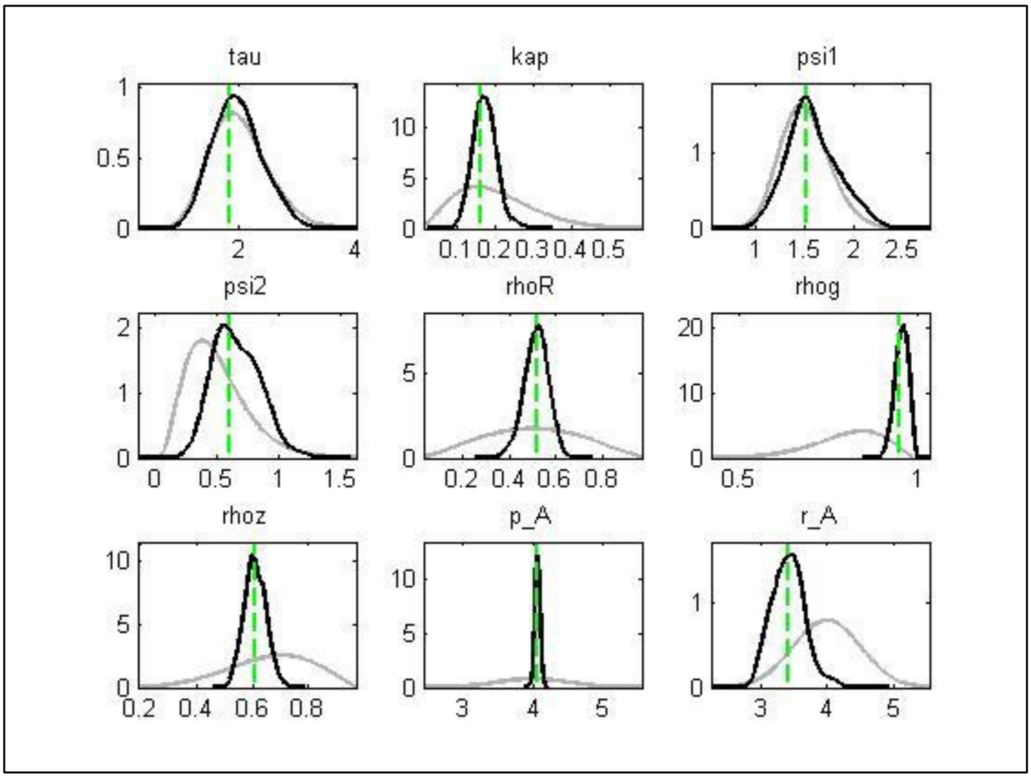

Figure 6: Comparison of the posterior and the prior distribution (1)

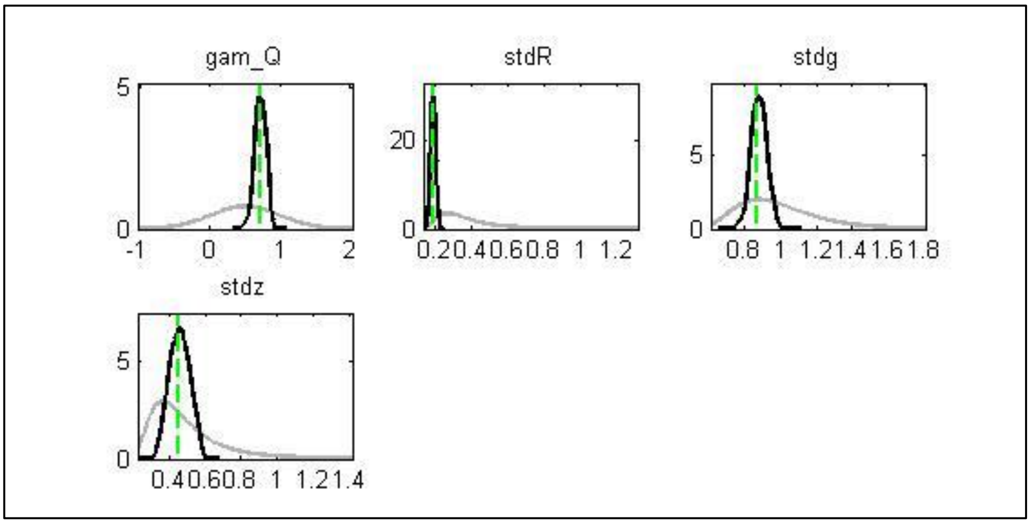

Figure 7: Comparison of the posterior and the prior distribution (2)

The grey area represents the distribution of the prior information (see task 3), the so-called prior distribution. The black area represents the combination of the likelihood (from the maximum-likelihood approach) and the prior distribution. This is the so-called posterior distribution. The two figures above show the comparison of the posterior and the prior for all (estimated) parameters.

If the posterior does not or barely differ from the prior, the used data does not contain much information for the estimation of the corresponding parameter. This overlapping of the two distributions can be seen for τ and ψ_1. For the other parameters the posterior distribution is more concentrated around the posterior mean (represented by the green line) compared to the prior distribution. This means that there is more probability mass around the posterior mean. This implies that we can now (after considering data) be more confident about which value the real parameter really take on. For some parameters the parameter uncertainty decreases rapidly through considering data (e.g. ρ_g, ρ_R). Therefore one can conclude that the used Bayesian estimation approach is useful. The estimation-result for ρ_R (for example) indicate that the smoothing behaviour of the central bank (regarding the interest rate) is indeed as low as expected ($\rho_R \approx 0.50$) .

Nevertheless it is important to say that a big data set is used (200 observations represent 50 years). Nevertheless τ and ψ_1 cannot be estimated more precisely with this method (identification problem). Consequentially Bayesian estimation is not always the best procedure/cannot solve all problems, but all in all the quality of this approach is good in this exercise.