Take-home Exam: Solution

Advanced Macroeconomics: Business Cycles

Fall 2018

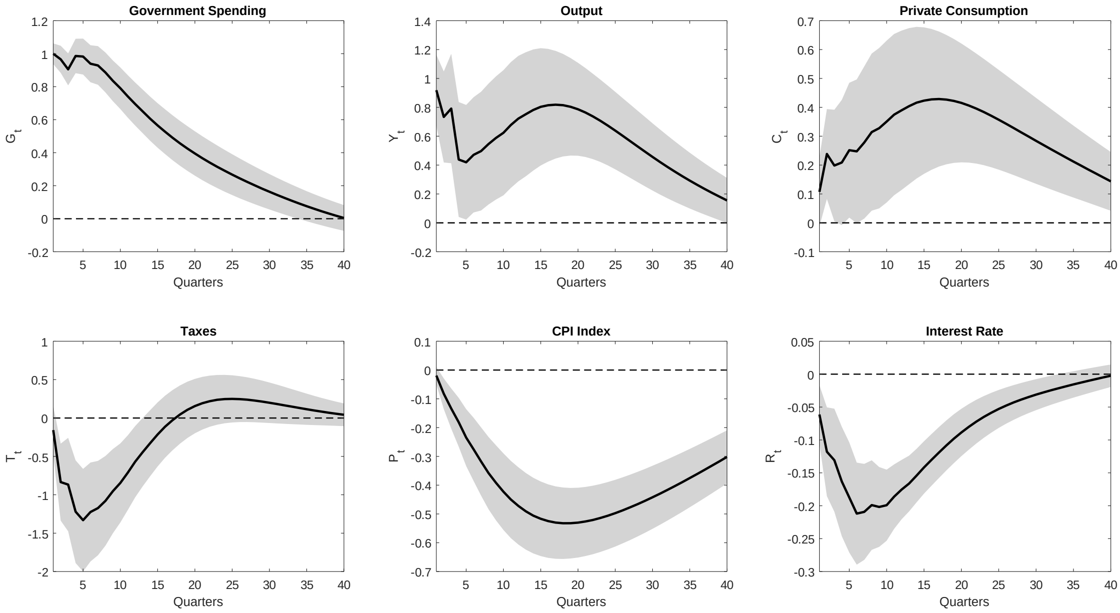
Part 1

Question 1 Codes for the estimation of VAR models have been made available during the course. Standard transformations implies taking the natural logarithm of all variables except R_t. For taxes, a constant needs to be added to avoid taking logs of a negative number (results may differ slightly depending on the choice of this constant). For the results that follow, all log variables have been multiplied by 100. A quadratic trend can be applied by setting the option 'tt = 3' in the codes distributed. The estimation itself (coefficient matrices etc.) need not be reported.

Question 2 In order to apply a Cholesky decomposition to identify a government spending shock, it is crucial that government spending is ordered first in the recursive ordering. This amounts to an implicit assumption that government spending cannot respond to changes in any other variable within-quarter. This is the identifying assumption proposed by Blanchard and Perotti (2002), who defend this assumption on two grounds: First, the *inside lag* associated with changes to government spending (i.e., the time it takes to decide on, pass, and implement new legislation about government expenditure) is rather long; in particular, longer than a quarter (the frequency of this dataset). Second, unlike government revenues, there is no automatic and within-quarter response of government spending to GDP (or any other variable in the system). These are the crucial assumptions students should mention. In addition, it is implicitly assumed that agents learn about government spending shocks only when they show up in the data. Students are not expected to discuss this assumption here, as it is the topic of Question 7. Concerning the ordering of the remaining variables, some different choices can be defended. For example, it is not obvious whether output or consumption should rank first. It seems natural, however, to rank the nominal interest rate last, since monetary policy has a very short inside lag and can respond to movements in the macroeconomy within-quarter. Students are expected to note this. The results below are based on the following ordering: $[G_t, Y_t, C_t, T_t, P_t, R_t]$.

Question 3 Ex ante, prices are expected to increase in response to a positive shock to government spending. In the baseline New Keynesian model with government spending, for example, an increase in aggregate demand induces firms to raise their prices, although some firms may not be able to do so due to price rigidities. During the course, it was discussed that the baseline New Keynesian model (as well as the baseline Real Business Cycle model) has severe problems in accounting for the effects of government spending shocks observed empirically. Instead, a model with rule-of-thumb households was able to generate the observed increase in private consumption. However, this model is unlikely to generate a decline in prices: In that model, the presence of rule-of-thumb households amplifies the increase in aggregate demand with little effect on aggregate supply, thus driving up prices by even more than the baseline model.

Question 4 The impulse-responses of all six variables, including the bootstrapped 68% confidence bands, are plotted below. In the figure, the responses of all variables have



been normalized in order to display a unit shock to G_t, and the response of output (and consumption) has further been normalized by the ratio of government spending to output (consumption), so as to directly observe the fiscal multiplier. The output multiplier is slightly below 1 according to the estimated IRF, both on impact and at the second peak, which occurs after around 4 years. The responses of output and consumption are in line with those in the empirical literature studied in class, in particular Blanchard and Perotti (2002): Output increases on impact and then displays a second peak 3-4 years after the shock, while private consumption increases significantly and with a delay. Turning to prices, we observe a significant and persistent decline in the price level. This is in stark contrast to the response one would expect on theoretical grounds, as discussed in the previous question. These results seem to indicate a "price puzzle" for fiscal policy not unlike the one studied during the course for monetary policy. The result that prices drop significantly is not sensitive to the placement of prices in the recursive ordering (it can be placed anywhere after G_t).

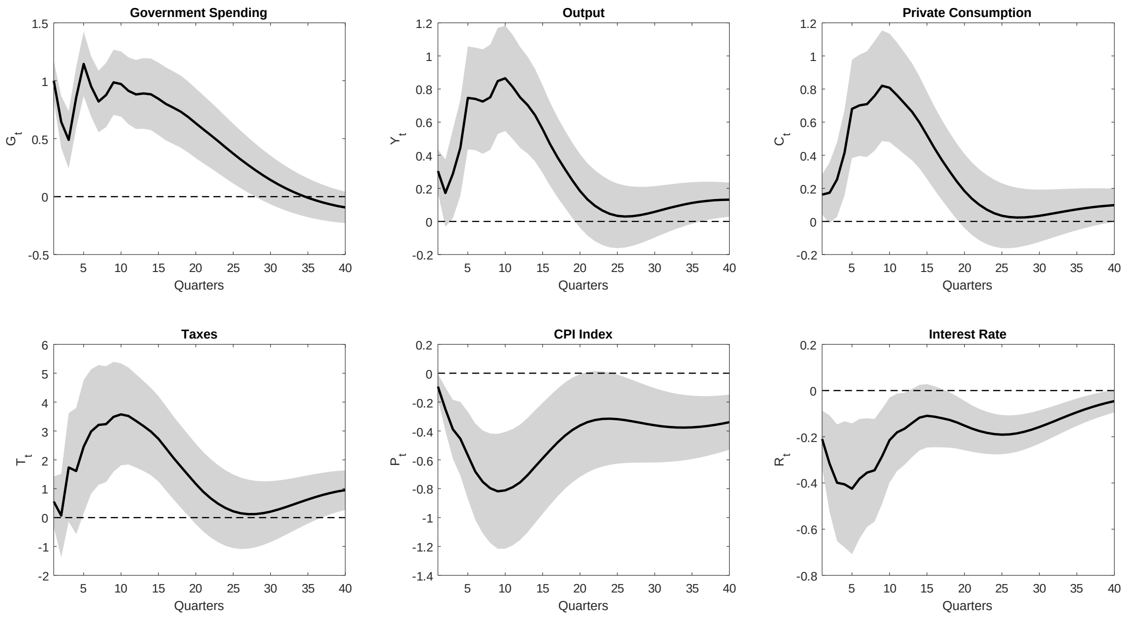
Question 5 This is a rather open question where students are invited to use their economic intuition. There is not a single correct response that they are expected to come up with. It is fine if students check whether the inclusion of commodity prices can change the results (it does not). However, the case for including commodity prices seems less clear in the case of fiscal than with monetary policy: While monetary policymakers react to a range of variables, and would be expected (at least under inflation targeting) to consider recent developments in commodity prices to gauge the upcoming inflationary pressure before setting the interest rate, the argument that fiscal policymakers is (even partially) driven or affected by commodity price fluctuations appears more far-fetched. Students are expected to note this, and it is therefore fine if they dismiss this hypothesis altogether and do not report results with commodity prices added to the VAR model.

Question 6 The implicit assumption in the Cholesky ordering (provided that students placed the price level *after* government spending in Question 2, as they should) is that there is no within-quarter effect of a change in the price level on real government spending, i.e. that this elasticity is zero. If a change in the price level is to have no effect on *real* government spending, it must be because *nominal* government spending is fully indexed to the rate of inflation. This is not quite realistic. A substantial chunk of government spending goes to wages, which are typically indexed to the rate of inflation, although not necessarily on a quarter-by-quarter basis (more likely on an annual basis). Considering next the non-wage component of government spending, some categories of the government's purchases of goods and services are likely to be fully indexed: If the prices of the goods or services purchased by the government increase, then government spending automatically increases. All in all, the elasticity of real government spending with respect to prices is likely to be negative. This would tend to bias the response of prices in a downward direction, meaning that we are overestimating the drop in prices: When G_t increases, this leads to a drop in prices. If the "true" elasticity is negative as argued here, the drop in prices in itself leads to an increase in real government spending (that is missed in the Cholesky decomposition). This means that when computing $\frac{\partial P_t}{\partial G_t}$, we are effectively underestimating the change in government spending, ∂G_t, and therefore overestimating the effect on prices for a given increase in government spending, $\frac{\partial P_t}{\partial G_t}$.

Question 7 We now add FE_t to the set of variables in the VAR model. Importantly, this variable should be ordered first in the Cholesky ordering, so as to be consistent with the interpretation of it as a forecast error, cf. Auerbach and Gorodnichenko (2012). The ordering of the remaining variables is as above. To generate an unanticipated shock to government spending, students then need to give a shock to FE_t itself. The responses of the remaining variables are illustrated in Figure 2. As the figure shows, the previous results are generally confirmed using this approach, at least from a qualitative viewpoint. In particular, the drop in prices appears to be robust to this identification scheme, although the drop is somewhat smaller and less persistent in this case. Note also that government spending increases also in this case, confirming that we have in fact identified a shock to unforecasted government spending followed by an actual increase in this variable.

Part 2

Question 1 During the course, students have mostly seen models of fiscal policy in which government spending is wasteful. It may seem more sensible to assume that government spending actually serves a purpose. One option is to add it to the utility function, but as long as utility is additively separable in government consumption and other entries (private consumption, leisure), this has no effect on economic outcomes (but



simply increases the level of utility). Another option is to include public capital in the production function. Students have briefly seen this during the course, following Baxter and King (1993). This may seem sensible in regard to some parts of government spending or investment, such as investments in infrastructure (roads, bridges, IT-infrastructure) or human capital formation (e.g., public education), although it is also possible to think of other parts where this assumption is less reasonable (e.g. care for the elderly, cultural spending). In this setting, we are assuming that all parts of government spending are productive (i.e., add to the public capital stock), but this assumption is probably way too optimistic.

Question 2 Letting λ_t denote the Lagrange multiplier associated with the budget, we obtain the following first-order conditions for the household:

$$\begin{aligned} C_t^{-\sigma} &= \lambda_t, \\ N_t^{\varphi} &= \lambda_t W_t, \\ \lambda_t &= \beta \mathrm{E}_t \lambda_{t+1} \frac{R_t}{\Pi_{t+1}}, \end{aligned}$$

which can be combined to yield:

$$N_t^{\varphi} = W_t C_t^{-\sigma},$$

$$C_t^{-\sigma} = \beta \mathrm{E}_t C_{t+1}^{-\sigma} \frac{R_t}{\Pi_{t+1}}.$$

In log-linear terms, we obtain:

$$\varphi n_t = w_t - \sigma c_t, \tag{1}$$

$$-\sigma c_t = \mathrm{E}_t \left(-\sigma c_{t+1} + r_t - \pi_{t+1}\right). \tag{2}$$

The first-order condition for the firm's choice of labor is:

$$W_t = (1-\alpha) MC_{it} A N_{it}^{-\alpha} K_{gt}^{\alpha}.$$

In a symmetric steady state all firms are identical, so we can write:

$$W_t = (1-\alpha) MC_t A N_t^{-\alpha} K_{gt}^{\alpha},$$

which in log-linear terms becomes:

$$w_t = mc_t - \alpha n_t + \alpha k_{gt}. \tag{3}$$

Moreover, in log-linear terms (and again considering a symmetric steady state) we obtain the following expressions for the production function, the law of motion for public capital, and the goods market clearing condition:

$$y_t = (1-\alpha) n_t + \alpha k_{gt}, \tag{4}$$

$$k_{gt} = (1-\delta_g) k_{gt-1} + \delta_g g_t, \tag{5}$$

$$y_t = \frac{C}{Y} c_t + \frac{G}{Y} g_t. \tag{6}$$

The monetary policy rule in log-linear terms reads as:

$$r_t = \phi_\pi \pi_t + \phi_y y_t. \tag{7}$$

Finally, the exogenous process for government spending is given by:

$$g_t = \rho_G g_{t-1} + \varepsilon_t^G. \tag{8}$$

The model thus consists of equations (1)-(8) and the New Keynesian Phillips Curve provided in the exam text, repeated here for convenience:

$$\pi_t = \beta \mathrm{E}_t \pi_{t+1} + \lambda mc_t. \tag{9}$$

Question 3 Some of the assumptions made in this exercise are common in the business-cycle literature: This is the case for the assumption of log utility, and also to some extent for the assumption of unitary (inverse) Frisch elasticity of labor supply and the assumption that monetary policy reacts only to inflation. The assumption of no persistence in the shocks is less common, at least in models with an ambition of fitting the data, since government spending shocks are much more persistent in the data (as observed in the SVAR results). The assumption of full depreciation of the public capital stock is a bit uncommon, and effectively implies that current government spending has a direct and immediate effect on current output. However, it is useful to have a system with no state variables. Imposing the stated assumptions, we can combine (2) and (7) to obtain the first equation:

$$-c_t = \mathrm{E}_t \left(-\sigma c_{t+1} + \phi_\pi \pi_t - \pi_{t+1}\right). \tag{10}$$

It follows directly from this equation that when shocks have zero persistence, and all expected values are therefore zero, the economy's IS curve simply gives rise to a negative relationship between consumption and inflation ($-c_t = \phi_\pi \pi_t$) that is not affected by government spending shocks. Now start inserting into the NKPC (9) to obtain the second equation:

$$\begin{aligned}
\pi_t &= \beta E_t \pi_{t+1} + \lambda m c_t \Leftrightarrow \\
\pi_t &= \beta E_t \pi_{t+1} + \lambda \left[w_t + \alpha n_t - \alpha k_{gt} \right] \Leftrightarrow \\
\pi_t &= \beta E_t \pi_{t+1} + \lambda \left[n_t + c_t + \alpha n_t - \alpha k_{gt} \right] \Leftrightarrow \\
\pi_t &= \beta E_t \pi_{t+1} + \lambda \left[c_t + (1+\alpha) n_t - \alpha k_{gt} \right] \Leftrightarrow \\
\pi_t &= \beta E_t \pi_{t+1} + \lambda \left[c_t + (1+\alpha) \frac{y_t - \alpha k_{gt}}{(1-\alpha)} - \alpha k_{gt} \right] \Leftrightarrow \\
\pi_t &= \beta E_t \pi_{t+1} + \lambda \left[c_t + \frac{1+\alpha}{1-\alpha} y_t - \left(\frac{1+\alpha}{1-\alpha} + 1 \right) \alpha k_{gt} \right] \Leftrightarrow \\
\pi_t &= \beta E_t \pi_{t+1} + \lambda \left[c_t + \frac{1+\alpha}{1-\alpha} y_t - \frac{2\alpha}{1-\alpha} k_{gt} \right] \Leftrightarrow \\
\pi_t &= \beta E_t \pi_{t+1} + \lambda \left[c_t + \frac{1+\alpha}{1-\alpha} \left(\frac{C}{Y} c_t + \frac{G}{Y} g_t \right) - \frac{2\alpha}{1-\alpha} k_{gt} \right] \Leftrightarrow \\
\pi_t &= \beta E_t \pi_{t+1} + \lambda \left[\frac{(1+\alpha)\frac{C}{Y} + 1 - \alpha}{1-\alpha} c_t + \frac{1+\alpha}{1-\alpha} \frac{G}{Y} g_t - \frac{2\alpha}{1-\alpha} k_{gt} \right]. \qquad (11)
\end{aligned}$$

The third equation simply becomes (since $\delta_g = 1$):

$$k_{gt} = g_t. \qquad (12)$$

We can solve this system using the method of undetermined coefficients. The conjectured solution is:

$$\begin{aligned}
c_t &= \Psi g_t, \\
\pi_t &= \Phi g_t, \\
k_{gt} &= \Lambda g_t.
\end{aligned}$$

For k_{gt}, we can immediately verify that this guess is correct, and that $\Lambda = 1$. Inserting our guess, and using that $\rho_G = 0$, we further obtain:

$$\begin{aligned}
-c_t &= \mathrm{E}_t \left(-\sigma c_{t+1} + \phi_\pi \pi_t - \pi_{t+1} \right) \Leftrightarrow \\
-\Psi g_t &= \mathrm{E}_t \left(-\sigma \Psi g_{t+1} + \phi_\pi \Phi g_t - \Phi g_{t+1} \right) \Leftrightarrow \\
-\Psi g_t &= \phi_\pi \Phi g_t \Leftrightarrow \\
\Psi &= -\phi_\pi \Phi. \qquad (13)
\end{aligned}$$

Further, we have:

$$\begin{aligned}
\pi_t &= \beta E_t \pi_{t+1} + \lambda \left[\frac{(1+\alpha)\frac{C}{Y} + 1 - \alpha}{1-\alpha} c_t + \frac{1+\alpha}{1-\alpha}\frac{G}{Y} g_t - \frac{2\alpha}{1-\alpha} k_{gt} \right] \Leftrightarrow \\
\Phi g_t &= \beta E_t \Phi g_{t+1} + \lambda \left[\frac{(1+\alpha)\frac{C}{Y} + 1 - \alpha}{1-\alpha} \Psi g_t + \frac{1+\alpha}{1-\alpha}\frac{G}{Y} g_t - \frac{2\alpha}{1-\alpha} \Lambda g_t \right] \Leftrightarrow \\
\Phi &= \lambda \left[\frac{(1+\alpha)\frac{C}{Y} + 1 - \alpha}{1-\alpha} \Psi + \frac{1+\alpha}{1-\alpha}\frac{G}{Y} - \frac{2\alpha}{1-\alpha} \right] \Leftrightarrow \\
\Phi &= \lambda \left[-\frac{(1+\alpha)\frac{C}{Y} + 1 - \alpha}{1-\alpha} \phi_\pi \Phi + \frac{1+\alpha}{1-\alpha}\frac{G}{Y} - \frac{2\alpha}{1-\alpha} \right] \Leftrightarrow
\end{aligned}$$

$$\begin{aligned}
\Phi \left[1 + \frac{(1+\alpha)\frac{C}{Y} + 1 - \alpha}{1-\alpha} \lambda \phi_\pi \right] &= \frac{1+\alpha}{1-\alpha}\frac{G}{Y}\lambda - \frac{2\alpha}{1-\alpha}\lambda \Leftrightarrow \\
\Phi \frac{\left[(1+\alpha)\frac{C}{Y} + 1 - \alpha \right] \lambda \phi_\pi + 1 - \alpha}{1-\alpha} &= \frac{1+\alpha}{1-\alpha}\frac{G}{Y}\lambda - \frac{2\alpha}{1-\alpha}\lambda \Leftrightarrow
\end{aligned}$$

$$\Phi = \frac{(1+\alpha)\frac{G}{Y} - 2\alpha}{\phi_\pi \left[(1+\alpha)\frac{C}{Y} + 1 - \alpha \right] + \frac{1-\alpha}{\lambda}}.$$

We then also get:

$$\Psi = -\phi_\pi \Phi \Leftrightarrow$$

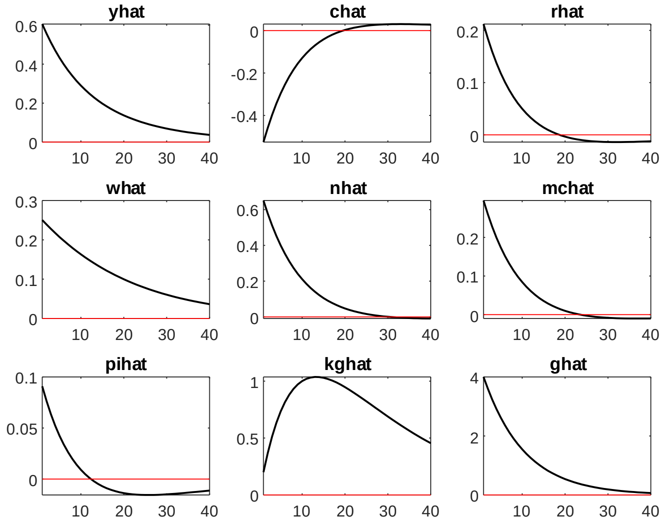
$$\Psi = -\frac{\phi_\pi \left[(1+\alpha)\frac{G}{Y} - 2\alpha \right]}{\phi_\pi \left[(1+\alpha)\frac{C}{Y} + 1 - \alpha \right] + \frac{1-\alpha}{\lambda}}.$$

We can thus write the solution as:

$$\begin{aligned}
c_t &= -\frac{\phi_\pi \left[(1+\alpha)\frac{G}{Y} - 2\alpha \right]}{\phi_\pi \left[(1+\alpha)\frac{C}{Y} + 1 - \alpha \right] + \frac{1-\alpha}{\lambda}} g_t, \\
\pi_t &= \frac{(1+\alpha)\frac{G}{Y} - 2\alpha}{\phi_\pi \left[(1+\alpha)\frac{C}{Y} + 1 - \alpha \right] + \frac{1-\alpha}{\lambda}} g_t, \\
k_{gt} &= g_t.
\end{aligned}$$

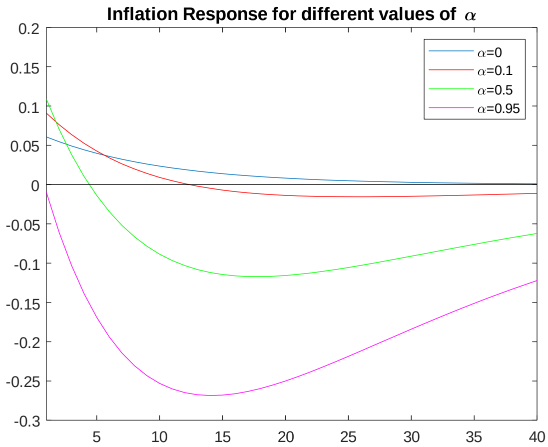
Question 4 The effect on k_{gt} of an increase in g_t is clearly positive. For inflation and consumption, the (common) denominator is clearly positive (as long as $\alpha < 1$). What about the numerator? The inflation response is negative, as in the VAR evidence, if and only:

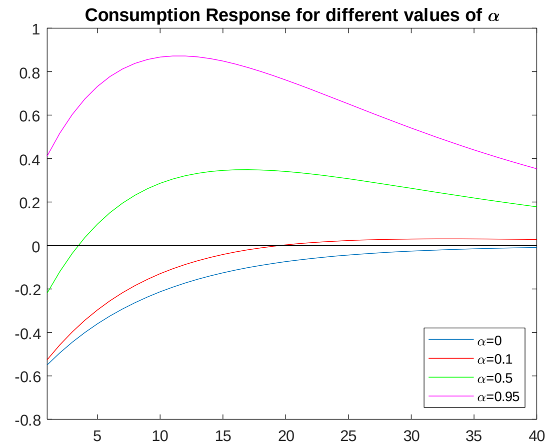
$$\begin{aligned}
(1+\alpha)\frac{G}{Y} - 2\alpha &< 0 \\
\alpha \left(2 - \frac{G}{Y} \right) &> \frac{G}{Y} \\
\alpha &> \frac{\frac{G}{Y}}{2 - \frac{G}{Y}}.
\end{aligned}$$



It is easy to verify that this is also the necessary and sufficient condition for the response of consumption to be positive. In other words, the simplified version of the model implies a drop in inflation and an increase in consumption on impact in response to a government spending shock if the weight of public capital in the production function is sufficiently high, i.e., if government spending is sufficiently productive. This is explained in more detail in the next two questions. Students are expected to note that not only is a drop in inflation consistent with an increase in consumption: one is necessary and sufficient for the other. With the baseline value of $\frac{G}{Y} = 0.25$, the condition above implies $\alpha > 0.14$. How to evaluate this number? It implies that government spending plays a modest yet non-negligible role in the private sector's production function. Baxter and King (1993) show that the government spending multiplier becomes very high (above 4) if the weight of public capital in the production function exceeds 0.1, which can therefore probably be regarded as an upper bound. Hence, a value of 0.14 is probably too high, although not grossly unrealistic.

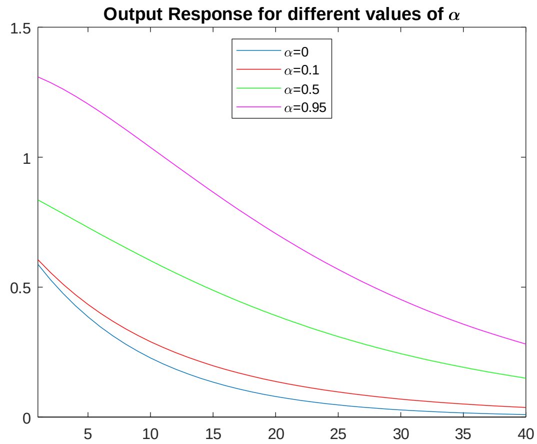
Question 5 The impulse responses of the variables in the model to an expansionary government spending shock are shown below. Here students should point out that while some variables seem to move in accordance with the empirical findings, the DSGE model is unable to reproduce some other key empirical findings from the SVAR model. Output increases in response to the shock, with a government spending multiplier that is somewhat lower than observed in the data (around 0.6 versus slightly below 1). This multiplier is outside the interval of available estimates summarized by Ramey (2011), who reports an interval of $0.8 - 1.5$. Two key variables display the exact opposite movement compared to the empirical findings: In the data, consumption increases while inflation declines. In the DSGE model, the opposite is true. Thus, the model generates the right type of opposite comovement between these two variables, but of the wrong sign. Regarding consumption, students should note that this is in line with the material covered during the course, whereas the response of prices





has not been studied before. Finally, also the interest rate goes up in the model while it declines in the data. The model thus has important shortcomings in matching our empirical results. The intuition for the observed responses is that when government spending is productive, an increase in G_t leads—through the build-up of public capital over time—to a reduction in the marginal cost of the firms, all else equal. Effectively, it is as if the government spending shock was accompanied by a total factor productivity shock. The downward pressure on marginal costs coming from higher productivity contrasts with the upward pressure on marginal costs coming from wages, as firms push up the wage rate to hire more labor in order to accommodate the increase in aggregate demand. However, in equilibrium the latter effect dominates, so that marginal costs and inflation increase. The central bank responds by raising the nominal and real interest rate, which induces households to save more, so consumption drops (and the increase in output is dampened).

Question 6 The responses of inflation, consumption, and output for different values of α are reported in the figures below. The first graph illustrates that a rather high value of α is required to observe a decline in inflation, especially on impact. Correspondingly, the second graph shows that the same is required for consumption to increase.



Values of α above 0.5 are required to observe such movements at all, but in that case only with a substantial delay, in contrast with the empirical evidence. To obtain the desired effects already on impact, only the graph for $\alpha = 0.95$ appears to do the job (although of course additional values of α between 0.5 and 0.95 may be sufficient). The final plot shows the implied government spending multipliers: The multiplier is around 0.6 for low values of α, rising to around 0.85 and 1.3 for the two high values. In other words, the government spending multiplier remains within reasonable values. The intuitive explanation behind the findings is as follows: When α is high, government spending is more productive. This means that an increase in government spending has higher chances of leading to a reduction in marginal costs: As discussed in the previous question, the productivity gain associated with productive government spending exerts a downward pressure on marginal costs. If this effect is sufficiently strong (i.e., α is sufficiently high), this effect dominates relative to the upward pressure on marginal costs coming from wages. In that case, marginal costs drop, so firms can reduce their prices, and inflation declines. The central bank now reduces the nominal interest rate (in line with the empirical evidence), which paves the way for an increase in consumption through the lower real interest rate.

Question 7 The minimum value of α required to generate an impact decline in inflation is 0.92 (rounded to two decimals). This value is much higher than the one obtained in Question 4. It seems unrealistic that government capital should play such a large role in the private sector's production function. As noted in Question 4, already a value of 0.14 was probably on the high end, so students should conclude that if $\alpha > 0.92$ is necessary, then probably the approach taken in this model falls short of explaining the empirical results, and that other model ingredients are required; perhaps in combination with the current approach, as it does seem to go in the right direction. The associated government spending multiplier is around 1.27-1.28. This number is on the high end of the available estimates, as reviewed, e.g., by Ramey (2011), but not in itself unrealistic.

Question 8 The monetary policy rule is now:

$$r_t = \phi_\pi \pi_t + \phi_g g_t. \tag{14}$$

If students decide to answer this question analytically, they are of course allowed to make the same set of parameter assumptions as in Question 3. By inserting the modified policy rule into the Euler equation (2) and assuming $\sigma = 1$, we obtain:

$$-c_t = \mathrm{E}_t \left(-c_{t+1} + \phi_\pi \pi_t + \phi_g g_t - \pi_{t+1} \right).$$

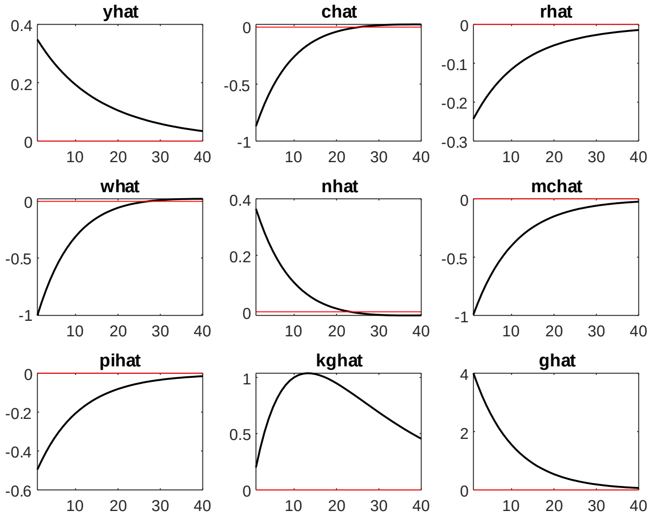
If we further assume that government spending shocks have no persistence, then expected values equal zero, and we have:

$$-c_t = \phi_\pi \pi_t + \phi_g g_t. \tag{15}$$

This version of the dynamic IS curve is different from the one obtained in the model version of Question 3, which did not feature the term $\phi_g g_t$. Thus, the 1:1 negative relationship between these two variables breaks down. If one were to represent this relationship graphically in (c_t, π_t)-space, we would observe a downward-sloping line that shifts *down* in response to a government spending shock if $\phi_g > 0$, and *up* if $\phi_g < 0$. In other words, if we are to have the best possible chance of observing a decline in π_t, we should impose $\phi_g > 0$. However, this would make it less likely that we observe an increase in consumption, all else equal. If students choose to go through all the steps in deriving the closed-form solution for inflation and output (which they are not expected to), then they should observe that all operations on the NKPC-expression are unaffected by the new policy rule, and they may impose that $k_{gt} = g_t$ as seen above. Following the same approach as in Question 3, we then obtain:

$$\begin{aligned} c_t &= \left[-\frac{\phi_\pi \left(-\phi_g \left[(1+\alpha) \frac{C}{Y} + 1 - \alpha \right] + (1+\alpha) \frac{G}{Y} - 2\alpha \right)}{\phi_\pi \left[(1+\alpha) \frac{C}{Y} + 1 - \alpha \right] + \frac{1-\alpha}{\lambda}} - \phi_g \right] g_t, \\ \pi_t &= \frac{-\phi_g \left[(1+\alpha) \frac{C}{Y} + 1 - \alpha \right] + (1+\alpha) \frac{G}{Y} - 2\alpha}{\phi_\pi \left[(1+\alpha) \frac{C}{Y} + 1 - \alpha \right] + \frac{1-\alpha}{\lambda}} g_t. \end{aligned}$$

Two things are worth noticing from these expressions: First, they collapse to the solutions obtained in Question 3 if we impose $\phi_g = 0$, as they should. Second, it can be seen directly that $\phi_g > 0$ makes it more likely to observe a decline in inflation (on impact). It is possible to show that consumption is less likely to increase (students are not expected to do this). The intuitive explanation is the following: If $\phi_g > 0$ then an increase in government spending is met with an increase in the nominal interest rate. This induces saving rather than consumption, which is therefore more likely to decline. This reduces aggregate demand, so inflation drops even further. Of course the explanation is the opposite if $\phi_g < 0$. The essence is that the monetary policy rule (14) leads to a trade-off between matching the response of inflation and that of consumption. If students choose to use numerical insights to answer the question, they are expected to maintain the baseline calibration from Question 5



(except that now $\phi_y = 0$), although other choices can be defended. The figure below reports the impulse responses to a government spending shock when doing so. In this case, the parameter ϕ_g has been set to 0.125. As seen from the figure, the increase in inflation observed in Question 5 has now been turned into a decline, in line with the empirical response. However, consumption now drops much more (almost twice as much) as observed in Question 5, reflecting the tradeoff between matching the consumption and inflation responses described above. Students may also note that the output multiplier is now below 0.4, which in itself is lower than available estimates, while on the other hand the observed decline in the nominal interest rate matches that observed in the SVAR evidence. Altogether, this approach thus seems to have some problems in explaining the data as well.

References

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[4] Ramey, V., 2011, Can Government Purchases Stimulate the Economy?, *Journal of Economic Literature* 49, 673–685.