1 Update - Apr 7th 2021

1.1 Multipliers

Experiment	no AD effects	AD only in Rec. states	AD in all states
Payroll tax cut	1	1.3	1.9
UI extension	1	1.9	2.2

Table 1: Long-run multipliers for each policy intervention

Difference to last update: UI multiplier lower (down from 5 to 1.9!). Reason was a bug that led to the UI extension being simulated under the assumption of no recession for SOME states, while the stimulus was calcuated under the assumption that the baseline was a recession.

1.2 Multipliers under different recession / policy lengths

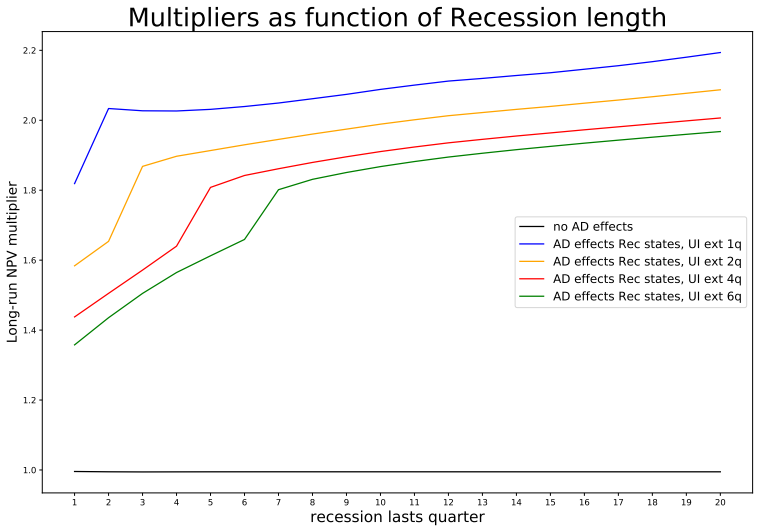


Figure 1

1. The longer the recesssion the higher the mulitplier: Clear!
2. For short recessions: the shorter the UI extension in length, the higher the multiplier. Reason: A higher share of the policy expenditure occur during the recession

3. For longer recessions: Still a difference but smaller. Probably because left-over spending still occuring during the end of the recession

4. Why do they not converge to the same level?

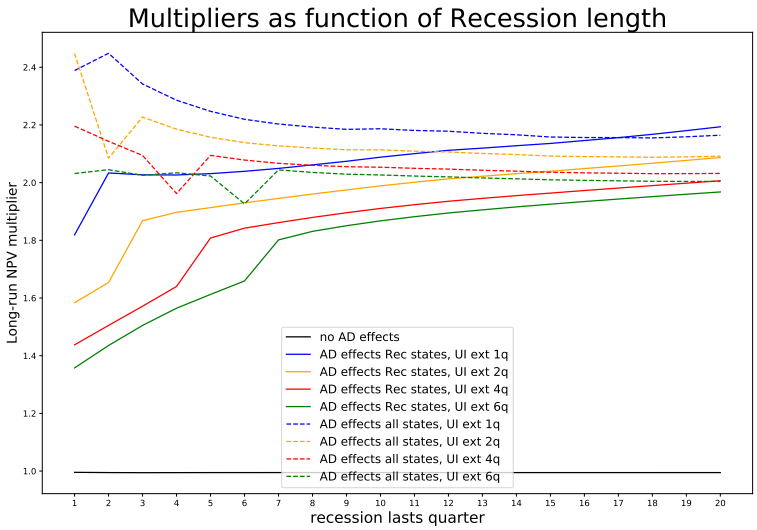


Figure 2

1. wiggly behaviour due to a known bug, should be more or less flat

2. The longer the recesssion the lower the multiplier. Reason: State does not matter anymore.

3. after 20q no diff between all states / only rec state curves

2 Update - March 24th 2021

2.1 UI extension - AD effects

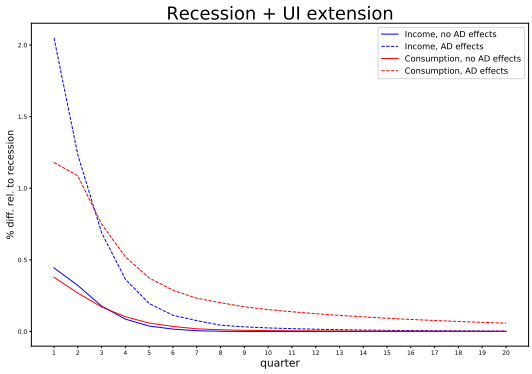


Figure 3: UI extension during recession, AD elasticity set to 0 (solid) or 0.5 (dashed)

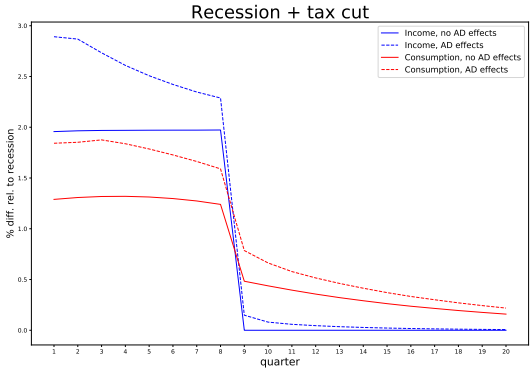


Figure 4: Payroll tax cut during recession, AD elasticity set to 0 (solid) or 0.5 (dashed)

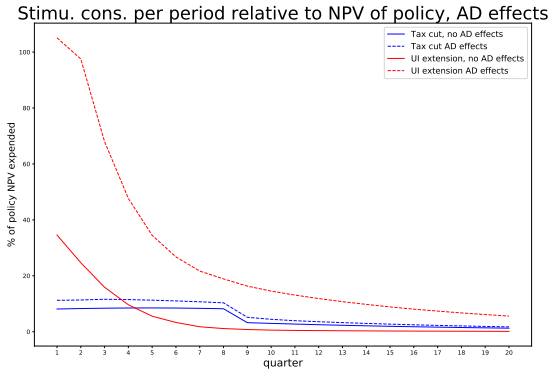


Figure 5: Policy experiments during recession; AD elasticity set to 0 (solid) or 0.5 (dashed)

2.2 Long-run (NPV) multipliers

Figure 6 shows the long-run multiplier for the payroll tax cut during a recession depending on the assumed elasticity of aggregate producitvity to demand (holding only in recession state). The multiplier for the payroll tax cut during a baseline is per construction 1 as the AD elasticity is zero in that case.

1. Payroll tax cut gives 2 % more income, leading to 1.3 % more consumption (for MPC of 0.65)
2. This leads to $(1.013)^{0.5}$ more income, hence a total increase in income by 2.65 %, implying a 1.7 % increase in consumption
3. This leads to$(1.017)^{0.5}$ more income, hence a total increase in income by 2.9 %, implying a .... % increase in consumption
4. and so on...

Alternative

1. Let us for arguments sake consider a 1q payroll tax cut increasing income by 1 % and the MPC is 1
2. Then for an AD elasticity of 1, the 1 % higher income leads to 1 % more consumption which leads to 1 more % income and again 1 % more consumption and so on forever
3. Let now assume the MPC is only 50 %, and the remaining 50 % are expended in q2
4. The likelihood that the recession is still there in q2 is 100 %

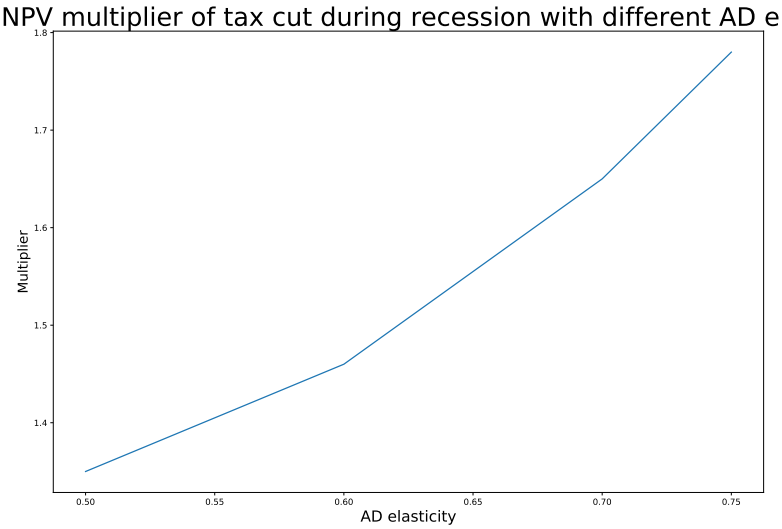


Figure 6

5. In q1: 1 % more income -¿ 0.5 % more consumption -¿ additional 0.5 % income -¿ 0.25 % more consumption -¿

6. In q2: 0.5 % more consumption -¿ 0.5% more income -¿ additional 0.25% consumption and so on...

7. Going through all qs gives high sum (not infinity though)

8. However, if recession ends, sum is reduced!

9. Also, the higher the initial MPC is the stronger will this cascade be and less important the length of recession

Table 2 shows the same information in form of a table including also the results for the Unemployment insurance extension.

Experiment \AD-Elas	0	0.2	0.5	0.75
Payroll tax cut	1	-	1.35	1.8
UI extension	1	2.4	5.6	-

Table 2: Long-run multipliers for each policy intervention for different AD elasticities

1. UI extension gives 0.5 % more income (10 % unepmloyed x 0.25 (additional replacement rate) x 20 % in need of extension), leading to 0.5 % more consumption (for MPC of 1 by unemployed)

2. This leads to $(1.005)^{0.5}$ more income, i.e. 0.25 % more income in the aggregate and continuing cascade

3. However larger share of spending expended during recession!

3 Update - March 10th 2021

3.1 Open question

- Absent AD effects, the NPV of fiscal policy intervention can be measured as: NPV of aggregate income in policy experiment - NPV of aggregate income without policy experiment
- But what about with AD effects?
- Cannot do the sasme calculation: NPV of aggregate income in policy experiment - NPV of aggregate income without policy experiment: The difference captures both policy expenditure as well as higher productivity
- Can we use the policy expenditure as calculated under no AD effects?

3.2 State-dependent AD elasticity

- Figure 7 shows additional income and consumption for tax cut during recession relative to recession with no tax cut, both when AD effects are present and when they are not
- AD effects, however, are state-dependent. Only in a recession we have an AD elasticity of 0.5
- Figure 8 shows a decomposition. Full results are the weighted (by recession length probality) sum of different simulations with increasing length of recession. If recession stops after few quarters, then AD elasticity jumps back to zero, such that the tax cut becomes less effective. As we progress in time, the likelihood that recession has ended becomes larger, such that that gets a larger weight in the weighted sum. Over time the weighted average AD effect drops.
- Problably some numerical issue with q1. Income drops more going from q1 to 2 in No Tax Cut recession.

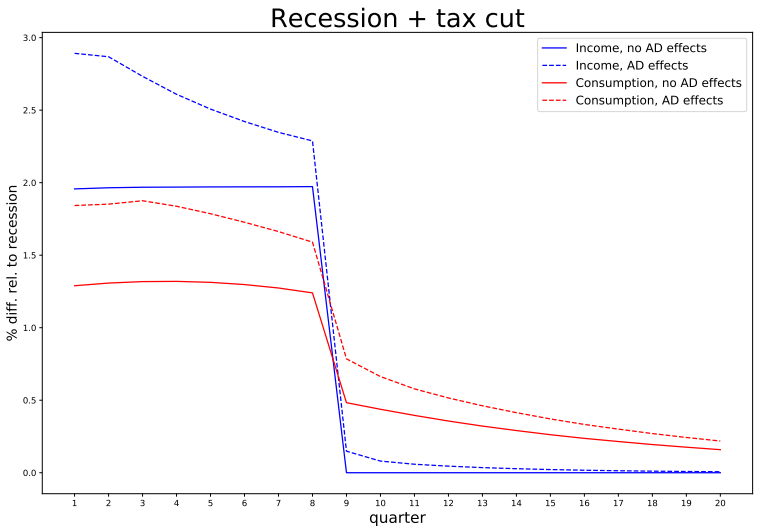


Figure 7

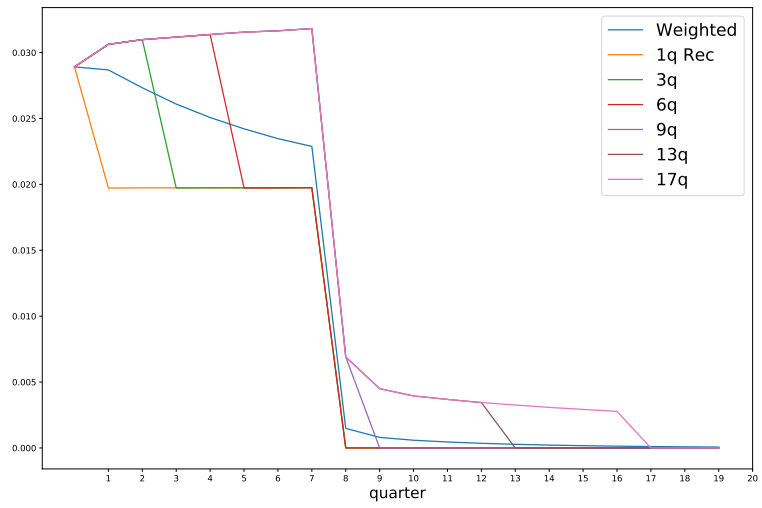


Figure 8

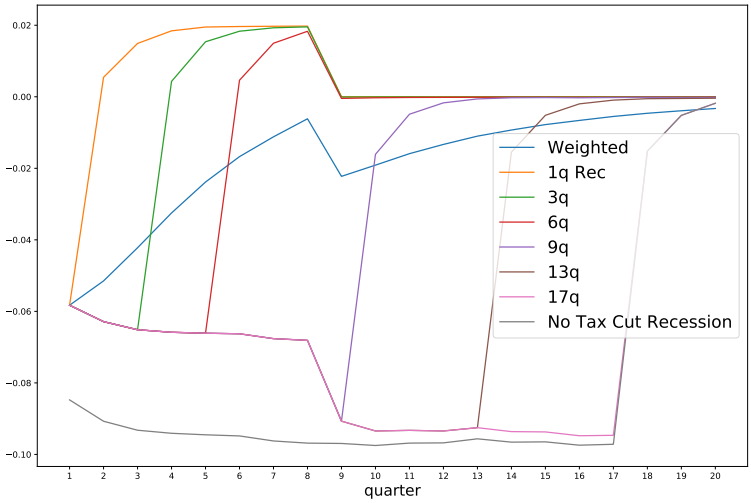


Figure 9

4 Update - February 24th 2021

4.1 Multipliers

- Figure 10 and 11 show different ways to plot spending / tax multipliers.
- The first figure shows the additional consumption created by the specific policy relative to the NPV of the total policy intervention. For example, about 35 % of the total NPV of the UI exentension is spend by households in the very first quarter. (The value is higher is higher outside of the recession because there is less need for precautionary saving.)
- The secon plot shows the perid by period multiplier. The value for q1 represents the impact multiplier. Hence, about 70 % of the additional income generated by the payroll tax cut is expended in each period, while 85 % of the additional unemployment benefits is spent.

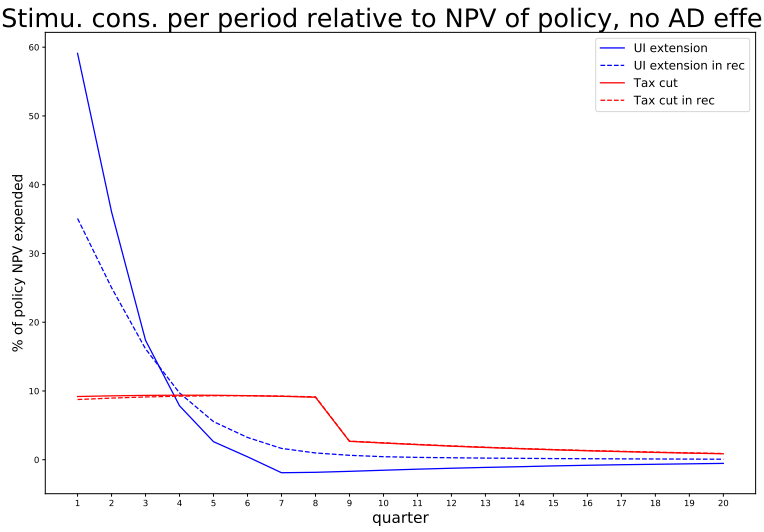


Figure 10

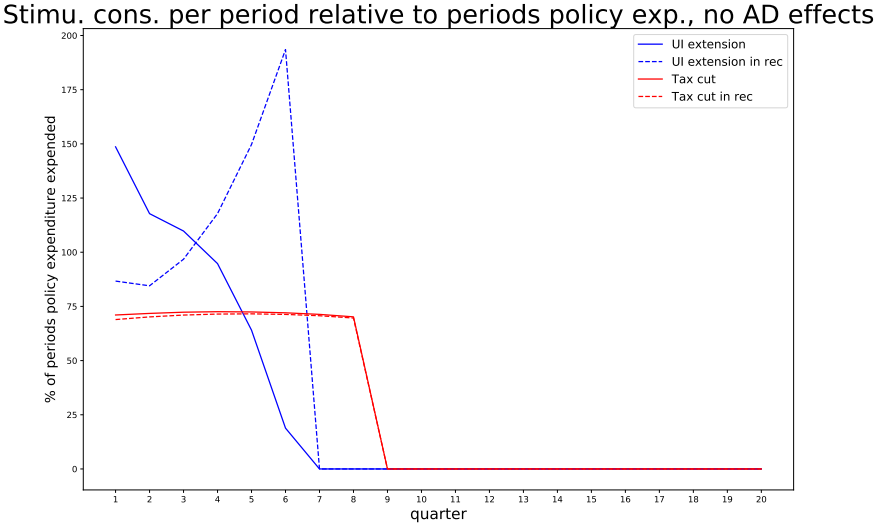


Figure 11

4.2 Continuation probability linked to business cycle state

- Figure 12: No AD effects
- Consider either 8q or 16 tax cut (black lines)
- Simulations: Conditional on recesssion lasting at least 9q (otherwise: probability of continuation only when recession in q8 is meaningless.)
- Consumption in the case of tax cut only occuring 8q long

  - Blue: Zero probability of continuation of tax cut after 8q

  - Green: 50% probability of continuation of tax cut after 8q (independent of business cycle)

  - Red: 50% probability of continuation of tax cut after 8q only when recession in q8: This curve is upward sloping as with the recession staying on it becomes more and more likely that tax cut will be extended

- Consumption in the case of tax cut being continued after q8

  - Green: 50% probability of continuation of tax cut after 8q (independent of business cycle)

  - Red: 50% probability of continuation of tax cut after 8q only when recession in q8

  - Orange: 100% probability of continuation of tax cut after 8q only when recession in q8

- Conclusion: Continuing the payroll tax cut even when recession ends does not boost consumption by much (except during first quarters) (see diff red green line). More stimulating is a guarantee to extend the tax cut in case of an ongoing recession.
- Figure 13: same but with AD effects

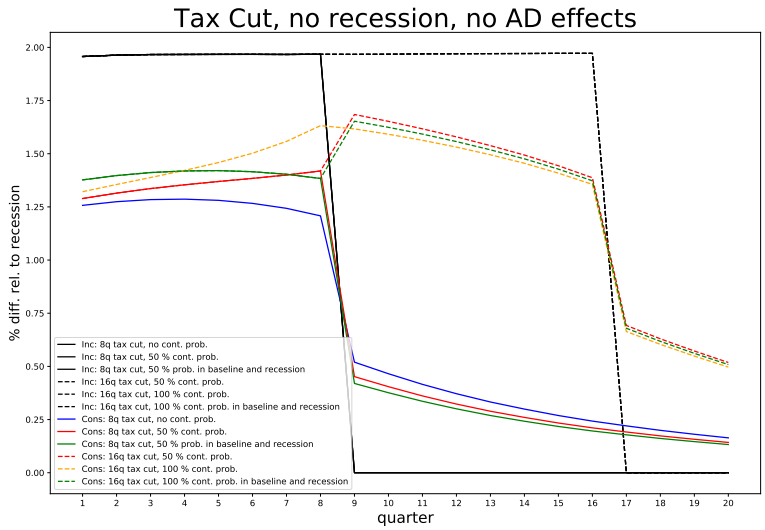


Figure 12

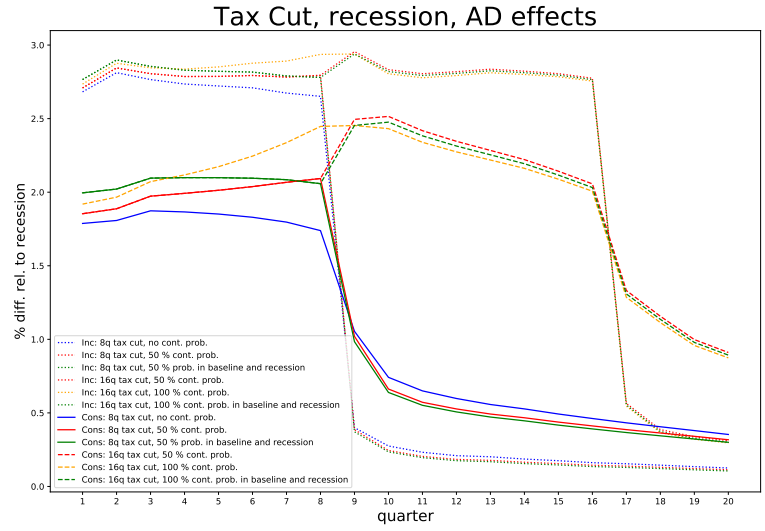


Figure 13

5 Update - February 10th 2021

5.1 Improved convergence

5.2 Tax cut

- We consider a payroll tax cut by 2 pp for 8q (deterministic length)
- See Figure 14

  The tax increases income and consequently pushes up consumption

  The drop in consumption in 9q is due to the fact that the splurge is applied to income in excess of the baseline income, which drops to zero after the tax cut is reversed. Consumption spending remains elevated for some time after the tax cut due to built up savings.

  With aggregate demand effects, the effect on consumption is larger as the increased consumption reinforces consumption through higher income due to higher TFP

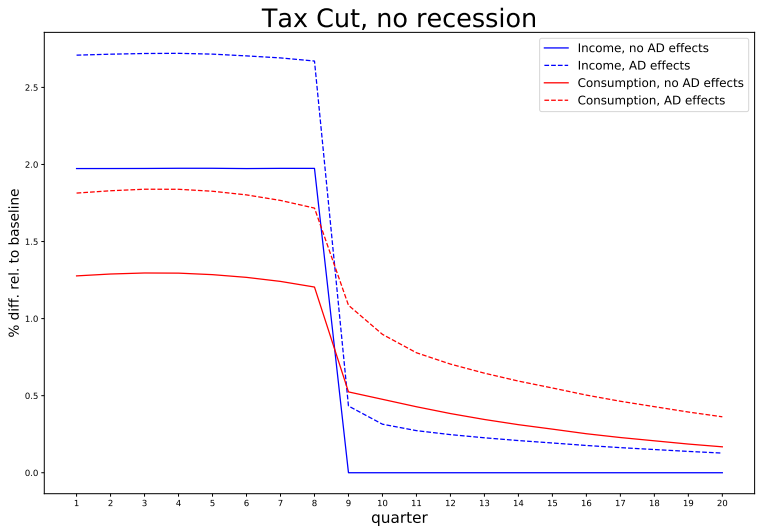


Figure 14

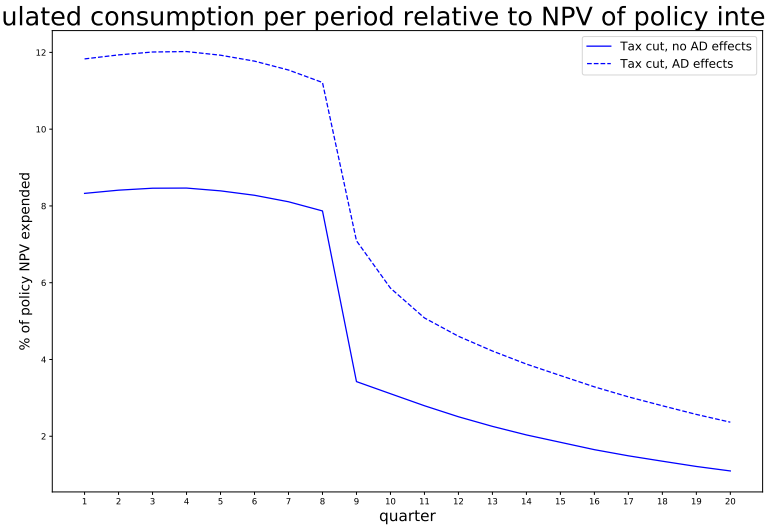


Figure 15

5.2.1 Recession

- We consider a recession with an expected length of 6 quarters, see Figure 16
- In a recession the unemployment rate increases to 10 % and lasts on average 4 quarters (as opposed to 5% / 1.5 q in normal times)
- The recession depresses aggregate income due to loss of labor income, only partly compensated by unemployment benefits (lasting 2 q, replacing 30 % of income)
- Consumption falls as income is lower.
- The recession is deeper when productivity depends on aggregate demand.

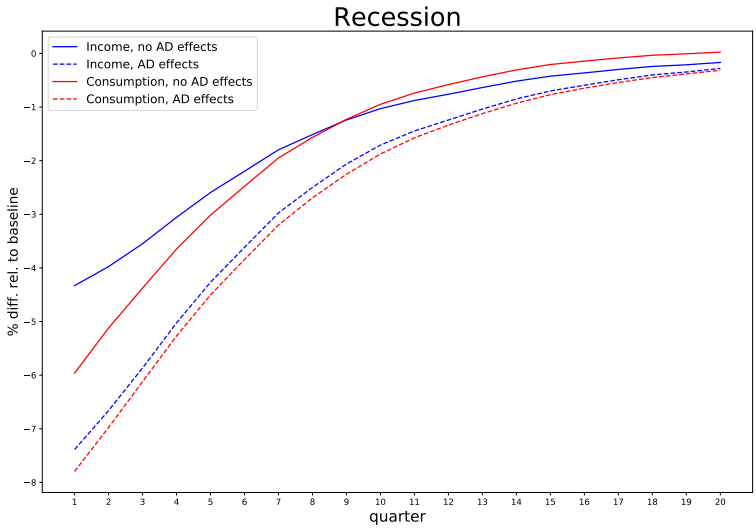
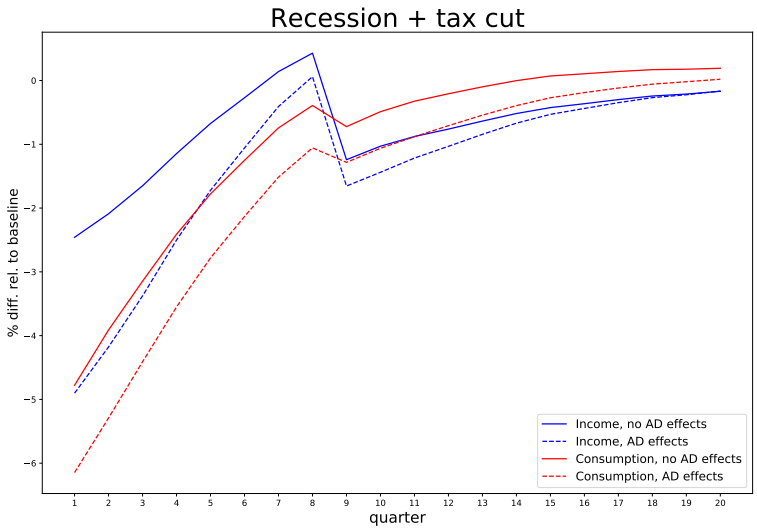


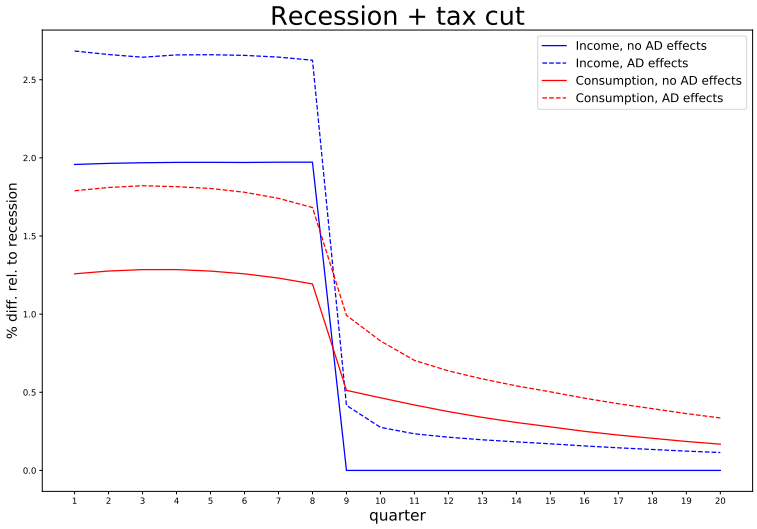
Figure 16

5.3 Tax cut during recession

- We consider a payroll tax cut by 2 pp for 8q (deterministic length) during a recession with an expected length of 6q
- Additional income / consumption relative to the baseline (see figure **??**) and to recession scenario (see figure **??**)
- When AD effects are switched off we obtain a similar result as in the baseline. However, note, that as the recession disappears, the additional income by the tax cut increases as more people are employed
- This upward trend in the effect of the tax cut is much more pronounced when considering AD effects. This is because very low consumption at the beginnning of the recession sets a much steeper recovery path.
- Not clear why consumption first drops (numerical error?)



(a) rel. to baseline



(b) rel. to recession

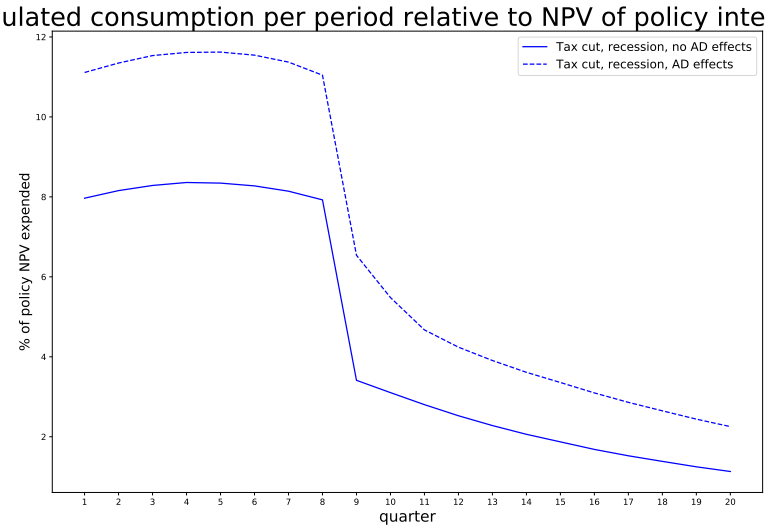


Figure 18

5.4 Deterministic length of the payroll tax cut vs. probability of continuation

We compare a payroll tax cut (of 2 percentage points) when the length of the payroll tax cut policy is deterministic and set to eight quarters vs. when there is a 50% chance (of which everyone is aware) of an continuation of the initial eight quarter of payroll tax cut by another eight quarters (and so on). We do so with and without aggregate demand (AD) effects.

- Figure 19 shows the payroll tax cut without AD effects
- Income increases for either 8 or 16 q depending on scenario
- Consumption during the first 8q is higher when there is a chance of continuation of the policy even if it does not materialize. If it does not materialize consumption in quarter 9 falls below the level relative to the scenario where continuation was excluded out in the first place, because consumption was based on the expected income.
- When the continuation actually occurs, agents increase consumption because actual income exceeds expected income.

- Figure 20 shows the payroll tax cut with AD effects

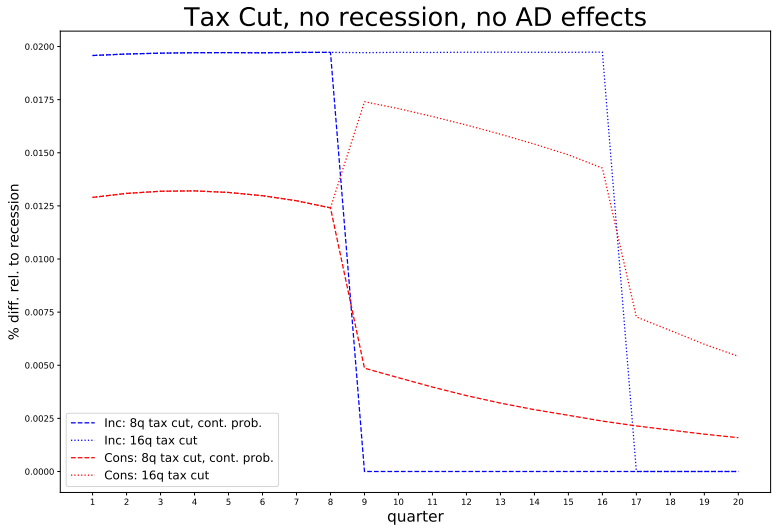


Figure 19

- Income increases for either 8 or 16 q depending on scenario. However, income now increase by more than 2% percent because of AD effects, implying an additional boost to income when the continuation of the payroll tax cut is implemented.

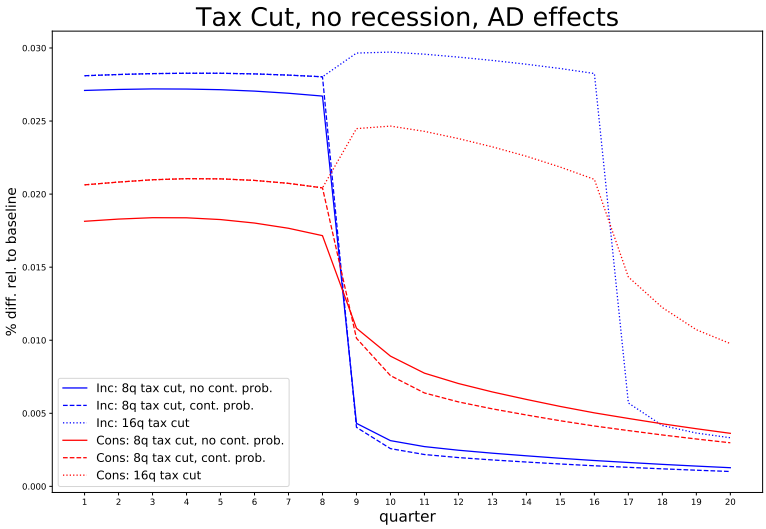


Figure 20

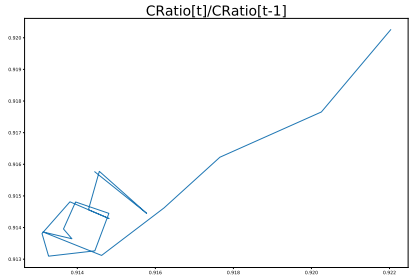
5.5 Sample size and speed of simulation

In the following we test the speed of the code for solving and running the recession scenario. We assume that there is one discount factor common to all agents.

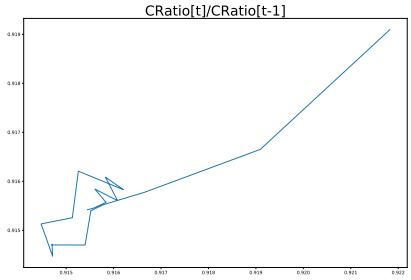
The following table shows the time needed to run the code, that i) solves the model without AD effects, ii) solves the model with AD effects and iii) simulates the considered scenario with and without AD effects.[1] The second point requires solving the model several times repeadetly with macroeconmic beliefs of agents being updated in each iteration. For this reason, this step is by far the most time-intensive. When solving the model with AD effects, the algorithm is terminated when the change in beliefs from one to the next iteration falls below a certain tolerance. The second and third row of the table compare two different levels of that tolerance.[2] Note, that while solving with more agents is somewhat slower, it actually helps the algorithm to find the AD solution with fewer iterations. Simulating the larger number of agents is much slower, however.

[1] 40 simulations are performerd here, i.e. recessions that last 1 to 20q, with and without AD effects.

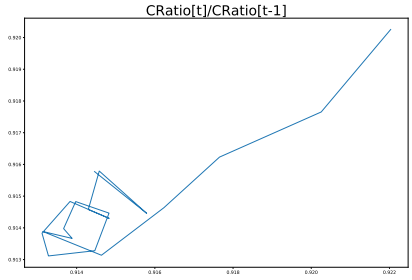
[2] The change is measured as the Euclidean norm of the difference in slopes and intercepts of the linear function on the consumption ratio, which agents use to predict future income.



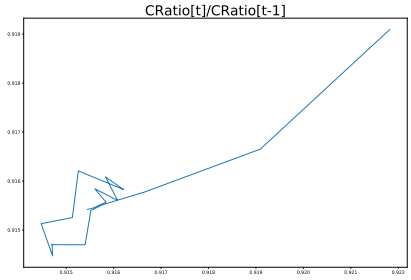
(a) Sample 50k, tol = 1E-3



(b) Sample 200k, tol = 1E-3



(c) Sample 50k, tol = 1E-4



(d) Sample 200k, tol = 1E-4

Figure 21: Plotting CR_t (y-axis) on CR_{t-1} (x-axis). (subfigure's title misleading, please ignore)

	Sample 50k	Sample 200k
Solving without AD	1 min	1 min 20 sec
Solving with AD (tol: 1E-3)	10 min (10 iter.)	12 min (7 iter.)
Solving with AD (tol: 1E-4)	22 min (20 iter.)	16 min (10 iter.)
Simulation	2 min 20 sec	16 min

Figure 21 plots CR_t on CR_{t-1} where CR_t is the ratio of simulated consumption to the baseline consumption in period t. The assumption behind our numerical algorithm to solve the model under AD effects is that individuals are able to predict the future consumption ratio, and thus their expected income (taking into account aggregate demand effects), based on a linear function of today's consumption ratio. If that assumption is correct, it should hold, that $CR_t = i + s(CR_{t-1} - 1)$. Hence, we should see a line with a constant gradient. As seen in the figure, this only holds approximately. A higher sample size somewhat improves the picture, a lower tolerance value for the convergence of macro beliefs does not.