# 1 Update - February 10th 2021

## 1.1 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.

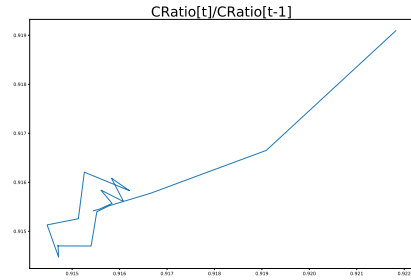|                              | Sample 50k        | Sample 200k        |
|------------------------------|-------------------|--------------------|
| Solving without AD           | 1 min             | 1 min 20 sec       |
| Solving with AD (tol: 1E-3)  | 10 min ( 10 iter.)| 12 min (7 iter.)   |
| Solving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

Figure 1 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.

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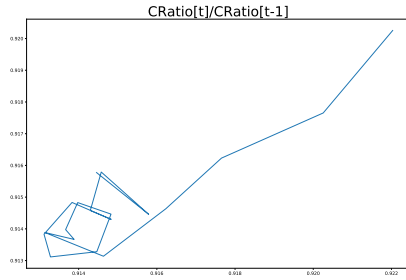[1]40 simulations are performerd here, i.e. recessions that last 1 to 20q, with and without AD effects.

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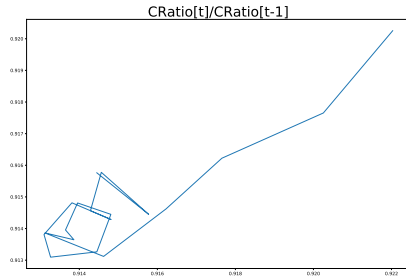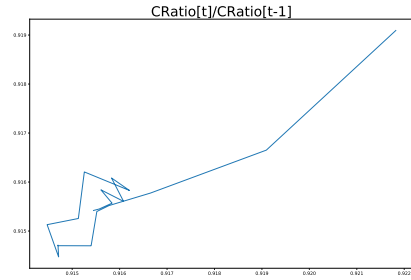
(a) Sample 50k, tol = 1E-3

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

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

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

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

# 2  Update - January 13th 2021

- Last call: impact of a payroll tax cut / extension of unemployment benefits on consumption; there were no aggregate demand effects

- Edmund created code to capture AD effects: Current consumption affects TFP: $TFP_t = \left(\frac{C_t}{C_{ss}}\right)^{\alpha}$ where $\alpha = 0.4$.

- What is working so far: AD effects for payroll tax cut experiment, for recession and for payroll tax cut during recession

- What is not working yet: AD effects for unemployment benefits extension

# 3  Stimulus Experiments

Parametrization

- Update probabiltity = 1 (have not tried sticky information yet)

- 7 discount factor groups: Beta = 0.986 (center), Nabla = 0.0183 (spread) as estimated on Norwegian Data

- Splurge = 0.32 as estimated on Norwegian Data

- Simulation of these results takes about 4 h (50k Agents, T-sim = 400)

## 3.1  Recession

- We consider a recession with an expected length of 6 quarters, see Figure 2

- 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.

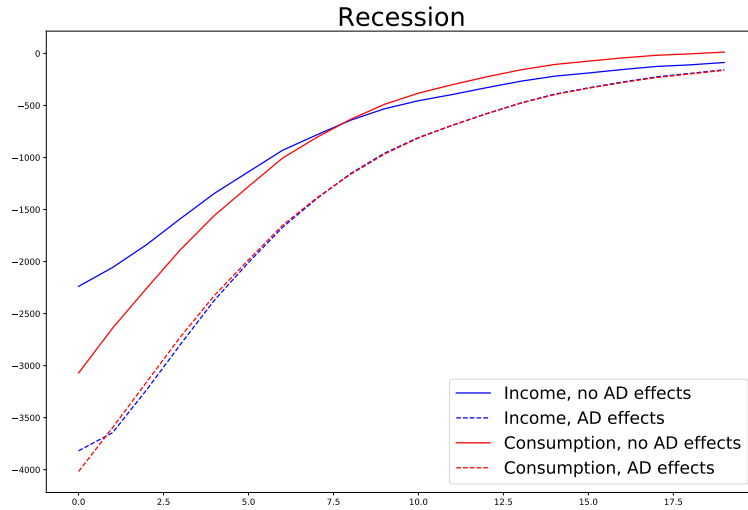- The recession is deeper when productivity depends on aggregate demand.

Figure 2: Recession

## 3.2 Tax cut

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

- See Figure 3

  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
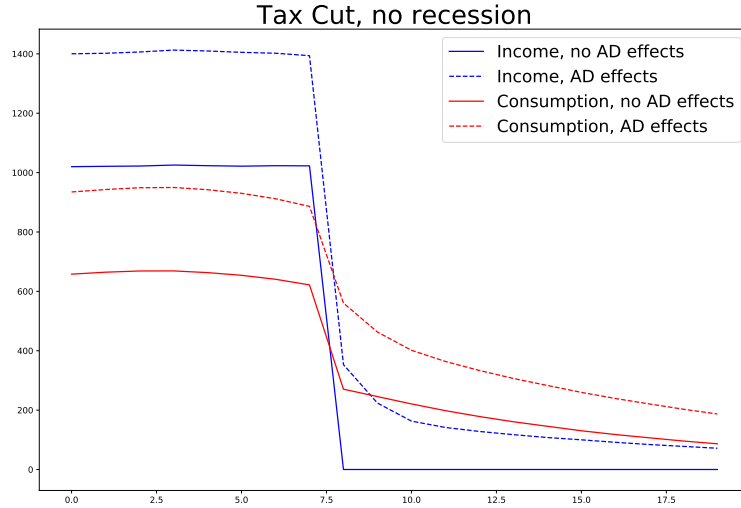
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Figure 3: Tax cut

## 3.3 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 4) and to recession scenario (see figure 5)

- 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.

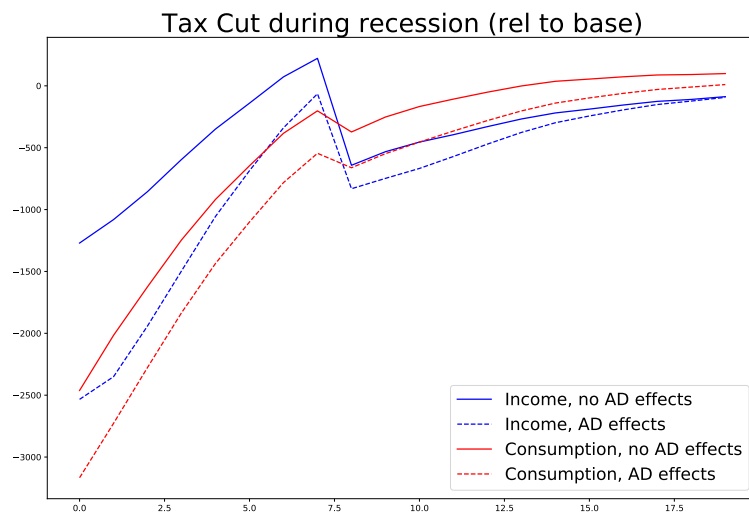- Not clear why consumption first drops (numerical error?)

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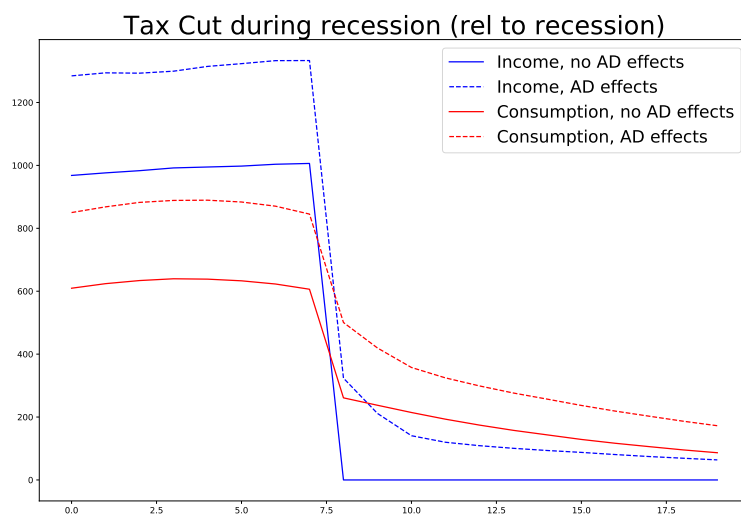Figure 4: Tax cut during a recession



Figure 5: Tax cut during a recession

## 3.4 [Preliminary] Comparing magnitude of stimulus relative to policy expenditure

- Figure 6 shows the additional consumption caused by the policy relative to the total net present value of the policy intervention

- However, we use the net present value from the no AD scenario

- This is problematic, need to calculate the amount of additional expenditure due to the fiscal policy intervention -¿ 2pp x recession-Ad-income

Figure 6: Stimulus