Guerrieri and Lorenzoni (2017) - Credit Crises, Precautionary Savings, and the Liquidity Trap

The paper of Guerrieri and Lorenzoni (2017) studies study whether a credit-crisis, modelled as a surprise tightening of the budget constaint, can explain the US experience in the recession that followed the Great Financial Crisis of 2007. This is done using, essentially, the model of Huggett (1993) with the addition of endogenous labour, and with a focus on general equilibrium transition paths.

Table 1 contains the parameters. The differences from the original reflect two things. Some are minor differences where I follow the values from the codes provided on Lorenzoni's website. The large differences (B and ϕ) are because I report the actual model parameters, while the GL2017 paper reports the model parameters as a fraction of annual model output (note that the model is quarterly; annual model output is general eqm is roughly 1.64). Obviously it is the actual parameter values that are needed when implementing the model.

A similar issue (actual values, versus value-as-a-fraction-of-annual-income) is present in many of the axes in the Figures from GL2017. This is fine, but often went unmentioned in the paper and so took some time to figure out when replicating. The replication codes produce both the versions that follow the 'figure descriptions' and those that follow the 'what is plotted'. I here only show those that follow the 'figure descriptions', and so the x-axes will sometimes appear different to the originals. Comments in the replication codes describe exactly which graphs this is relevant to.

Brief description of model is as follows. I present it in the form relevant to the replication codes, a fuller description is provided by Guerrieri and Lorenzoni (2017).

Households face the following value function iteration problem,

$$\begin{aligned} V(a,z) &= \max_{n,a'} \frac{c^{1-\gamma}}{1-\gamma} + \frac{1}{1-\omega}\psi\frac{(1-n)^{1-\eta}}{1-\eta} + \beta E[V(a',z')|z] \\ \text{s.t. } & c + \frac{1}{1+r}a' = a + zn - \tilde{\tau} \\ & a' \geq -\psi \end{aligned}$$

where n is labour supply, a is assets, z is exogenous labour productivity and follows a markov process. ω will be used as a 'wedge' to implement the 'New Keynsian sticky wage' transtion, but is otherwise zero. r is the interest rate to be determined in general equilibrium. $\tilde{\tau}$ is lump-sum net tax, which will be a lump-sum tax τ net of unemployment benefit v; $\tilde{\tau} = \tau - v\mathbb{1}_{(z=0)}$.[1] Note that GL2017 refer to z and θ, and set up model using $q = 1/(1+r)$. Household debt (negative values of assets, a) is bounded below by exogenous limit ψ.

There are two other main aspects to the model. The first is a Government which faces the following budget constraint:

$$\tau + \frac{1}{1+r}B' = uv + B$$

where B is government debt, and u is the unemployment rate (note that this will be equal to the probability that $z = 0$, which can be calculated directly from the transition matrix for exogenous

[1] You only receive unemployment benefits in the 'unemployment state' $z = 0$, you do not receive them based on choosing not to work ($n = 0$).

markov process on z). In the model the government is always considered to take everything but τ as exogenous and then simply set τ to ensure that this budget constraint holds (τ is thus determined in general eqm, but trivially so). The second main aspect is asset market clearance. The net private plus public asset supply must be equal to zero, which gives us that $B + \int a d\mu = 0$ (where $\mu(a,z)$ is agent distribution). General equilibrium will involve finding r to ensure asset market clearance (as in Huggett (1993)).[2]

Much of the replication involves solving stationary general equilibrium problems (finding r), and then general equilibrium transition paths (path of r) for a change/path in borrowing-limit ψ. There are also New-Keynesian general equilibrium transition paths (add restriction $r >= 0$, and use ω to ensure it holds), as well as some Fiscal and Fisher-deflation paths which largely add change/path in B and B' (and initial distribution of a). See GL2017 paper for details. The replication codes contain some clarifying comments about the exact timing of how to model these.

GL2017 state that they use Tauchen method to discretize AR(1) process for (log) z. They provide the parameter values of the AR(1) process (or more accurately the provide the 'annual values', together with formulae for calculating the quarterly value needed for the model). In code, GL2017 take their discretization of z (θ in the notation of paper) from Shimer (2005), and in their codes it is simply imported (i.e., there is no code that generates the actual values based on the properties of the AR(1)). It appears likely (but not known for a fact) that actually the Tauchen-Hussey method, a specific sub-version of the Tauchen method, was used to create the discretization. This choice of the Tauchen-Hussey method plays a very large role in their findings, but from the perspective of replication is perfectly fine. The only issue when replicating was that since Tauchen-Hussey was described as Tauchen, the paper did not report the hyperparameter value that would be required by Tauchen method.

Allowing for the 'different axes' in some of the Figures in this replication, everything replicates just fine.

References

Veronica Guerrieri and Guido Lorenzoni. Credit crises, precautionary savings, and the liquidity trap. Quarterly Journal of Economics, 132(2):1427–1467, 2017.

Mark Huggett. The risk-free rate in heterogeneous agent incomplete insurance economies. Journal of Economic Dynamics and Control, 17:953–969, 1993.

[2]Worth mentioning that there is an equivalence from the perspective of model behaviour when shifting both ψ and B, see GL2017 paper for detailed explanation.

Table 1: Table 1 of Guerrieri & Lorenzoni (2017)

Parameters Values

Parameter	Explanation	Value	Target/Source
β	Discount Factor	0.9774	Interest rate r=2.5%
γ	Coefficient of relative risk aversion	4	
η	Curvature of utility of leisure	1.5	Average Frisch elasticity=1
ψ	Coefficient on leisure in utility	15.88	Average hours worked 0.4 of endowment
ρ	Persistence of productivity shock	0.967	Persistence of wage process
σ_ϵ	Variance of productivity shock	0.017	Variance of wage process
$\pi_{e,u}$	Transition to unemployment	0.057	Shimer (2005)
$\pi_{u,e}$	Transition to employment	0.882	Shimer (2005)
υ	Unemployment benefit	0.17	40% of average labor income
B	Bond supply	2.7	Liquid assets (flow of funds)
phi	Borrowing limit	1.601	Total gross debt (flow of funds)

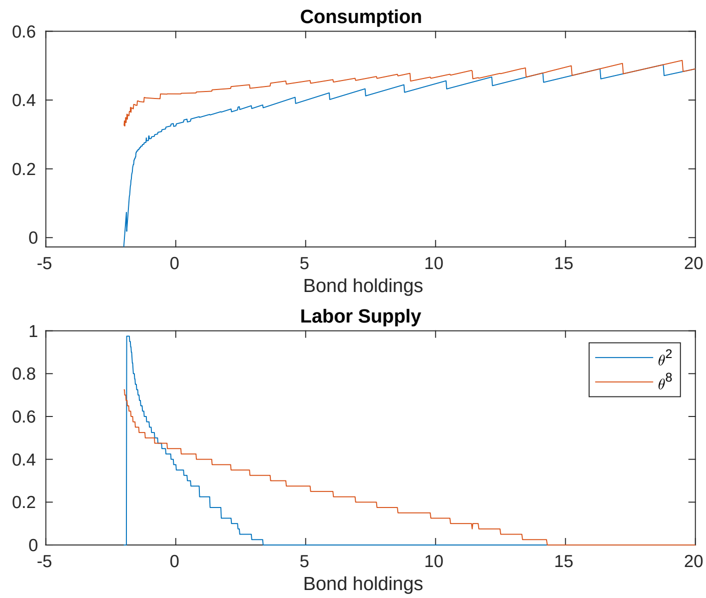
Note: values of B and phi differ from those in Guerrieri & Lorenzoni (2017). The actual model parameters are reported here, while those in paper are the parameter divided by annual output (annual output equals 4 times quarterly output; model is quarterly).

Table 2: Original Table 1 of Guerrieri & Lorenzoni (2017)

Parameter Values

Parameter	Explanation	Value	Target/source
β	Discount factor	0.9711	Interest rate $r = 2.5\%$
γ	Coefficient of relative risk aversion	4	
η	Curvature of utility from leisure	1.5	Average Frisch elasticity =1
ψ	Coefficient on leisure in utility	12.48	Average hours worked 0.4 of endowment (Nekarda and Ramey 2010)
ρ	Persistence of productivity shock	0.967	Persistence of wage process in Flodén and Lindé (2001)
σ_ε	Variance of productivity shock	0.017	Variance of wage process in Flodén and Lindé (2001)
$\pi_{e,u}$	Transition to unemployment	0.057	Shimer (2005)
$\pi_{u,e}$	Transition to employment	0.882	Shimer (2005)
ν	Unemployment benefit	0.10	40% of average labor income
B	Bond supply	1.6	Liquid assets (flow of funds)
ϕ	Borrowing limit	0.959	Total gross debt (flow of funds)

Note. See the text for details on the targets.



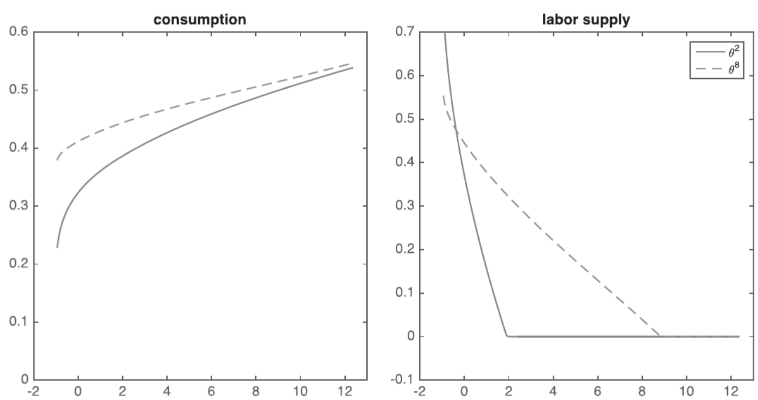
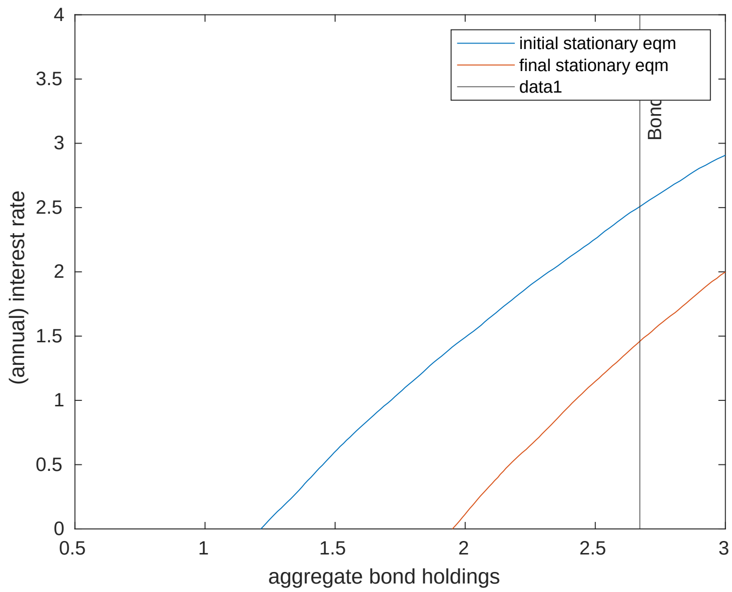


FIGURE I

Optimal Consumption and Labor Supply in Steady State

Figure 1: Figure 1 of Guerrieri & Lorenzoni (2017)



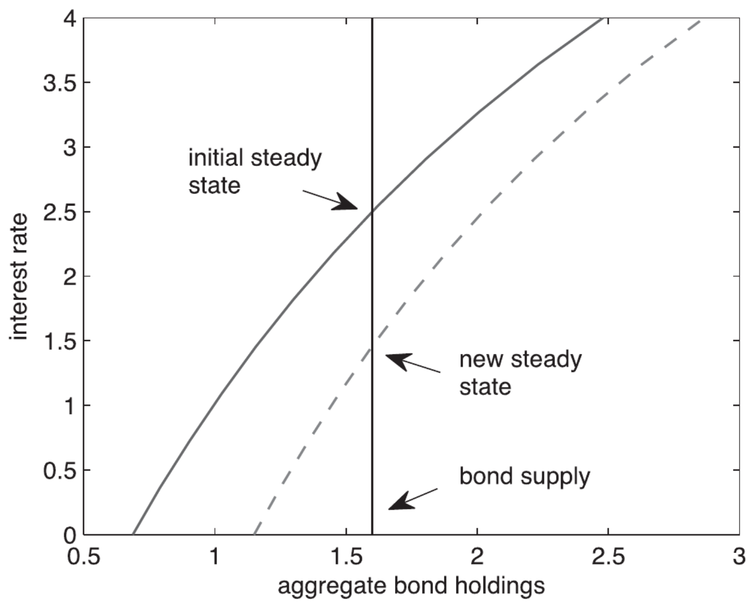
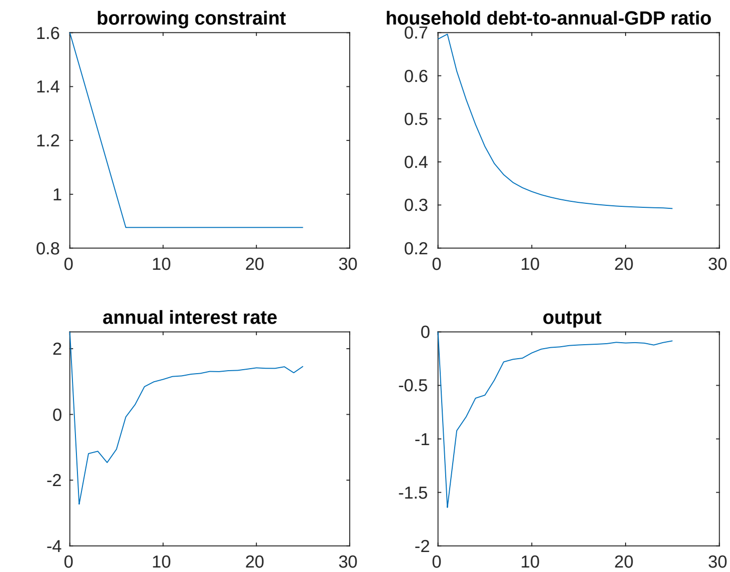


FIGURE II

Bond Market Equilibrium in Steady State

Interest rate is in annual terms.

Figure 2: Figure 2 of Guerrieri & Lorenzoni (2017)



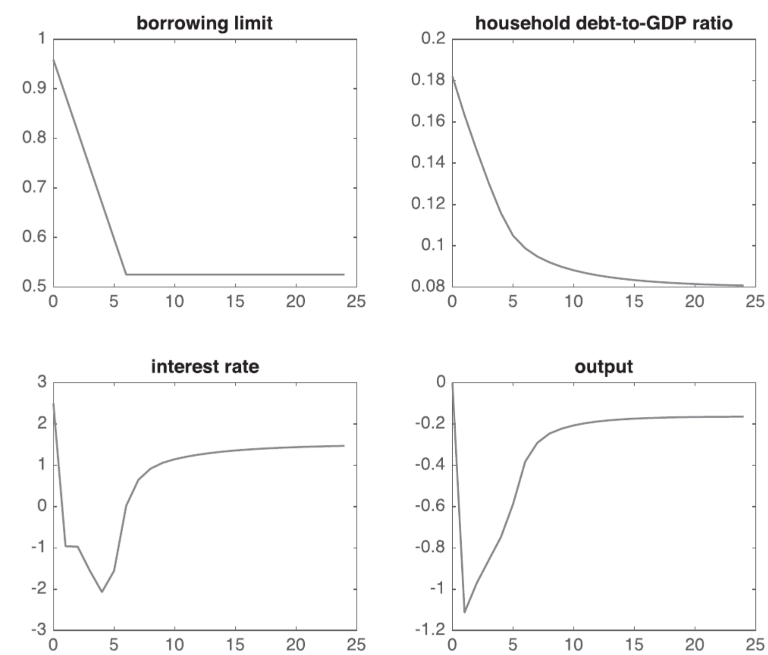
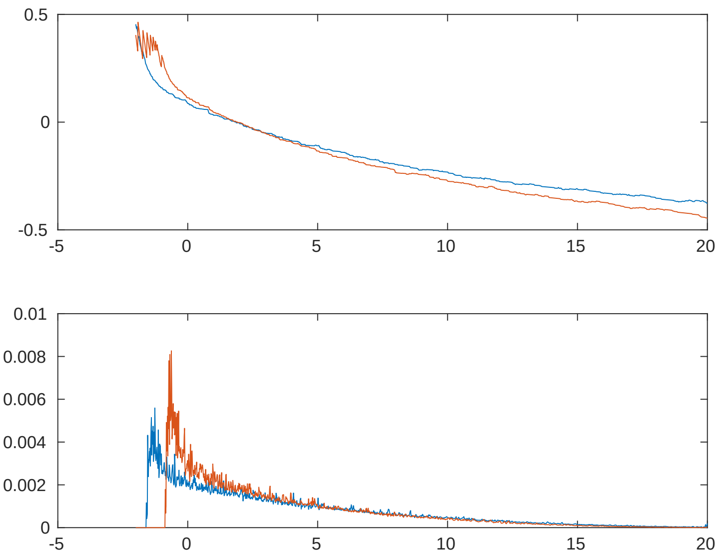


FIGURE III

Interest Rate and Output Responses

Interest rate is in annual terms. Output is in percent deviation from initial steady state.

Figure 3: Figure 3 of Guerrieri & Lorenzoni (2017)



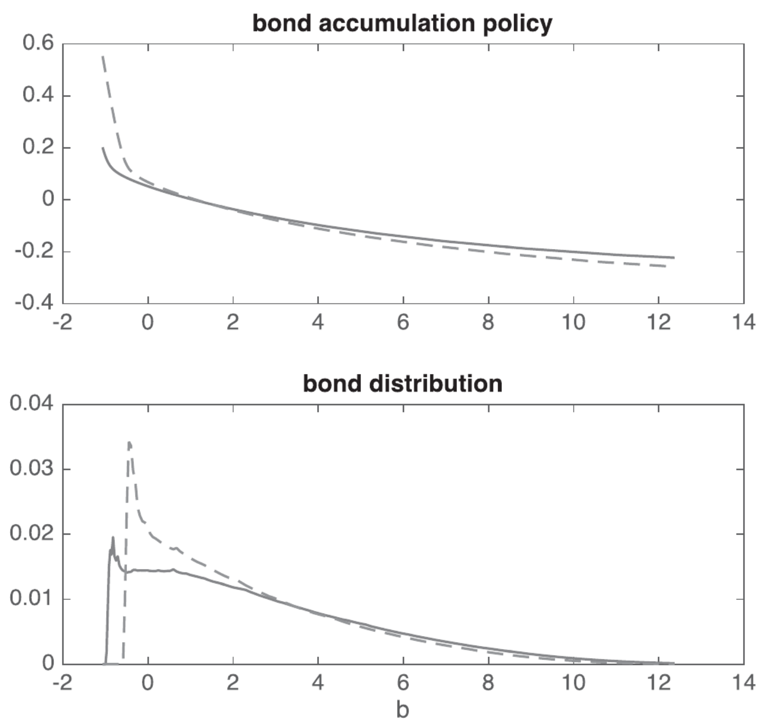
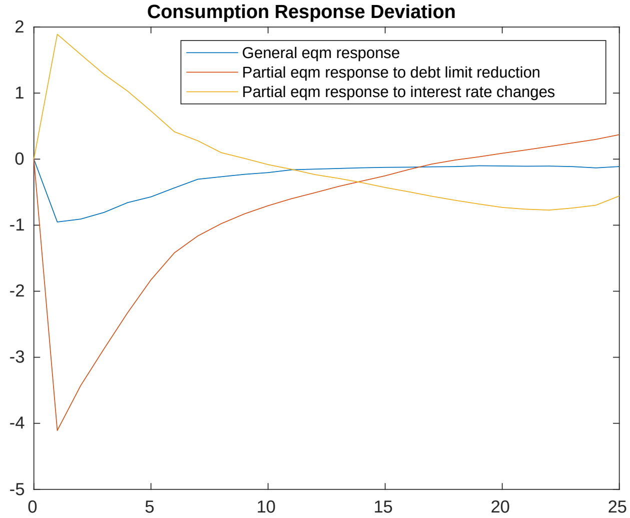


FIGURE IV

Bond Accumulation and Distributions in the Two Steady States

Solid line: initial steady state. Dashed line: new steady state.

Figure 4: Figure 4 of Guerrieri & Lorenzoni (2017)



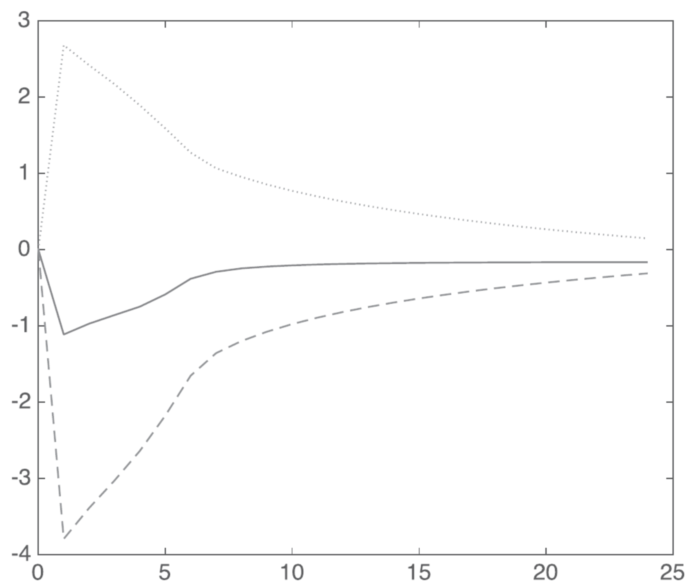
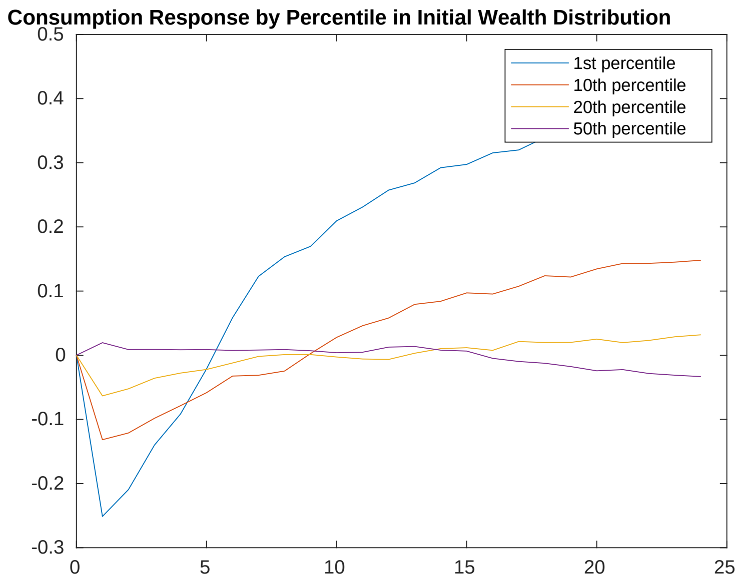


FIGURE V

Consumption Response Decomposition

Percent deviations from initial steady state. Solid line: general equilibrium response. Dashed line: partial equilibrium response to debt limit reduction. Dotted line: response to the equilibrium sequence of interest rate changes.

Figure 5: Figure 5 of Guerrieri & Lorenzoni (2017)



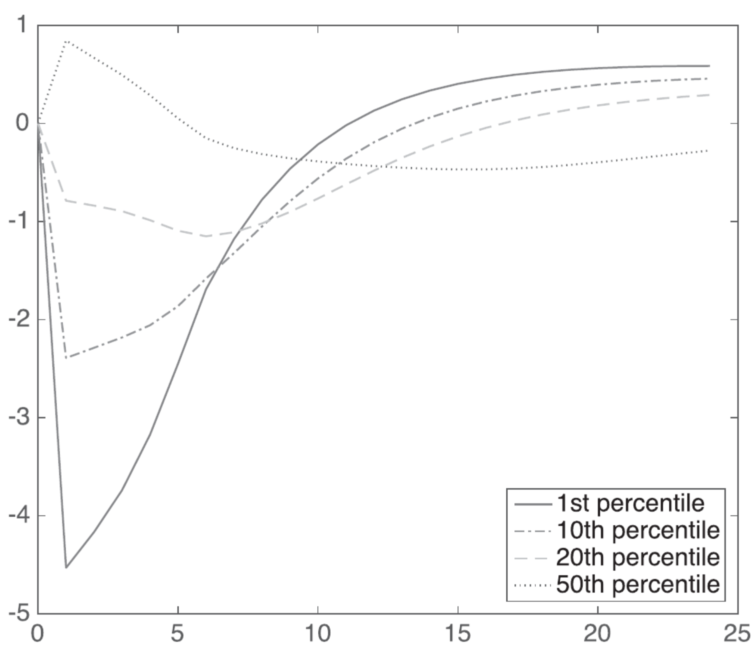
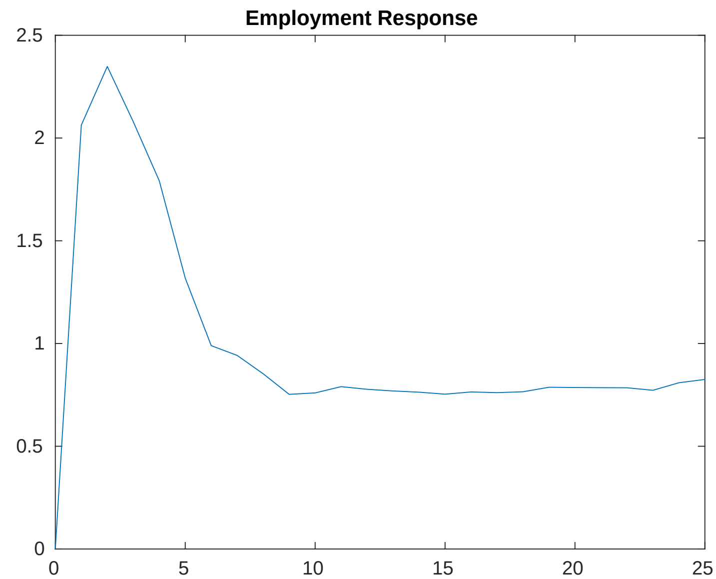


FIGURE VI

Consumption Response by Percentile in Initial Wealth Distribution

Percent deviations from steady-state path conditional on initial wealth being in the reported percentile.

Figure 6: Figure 6 of Guerrieri & Lorenzoni (2017)



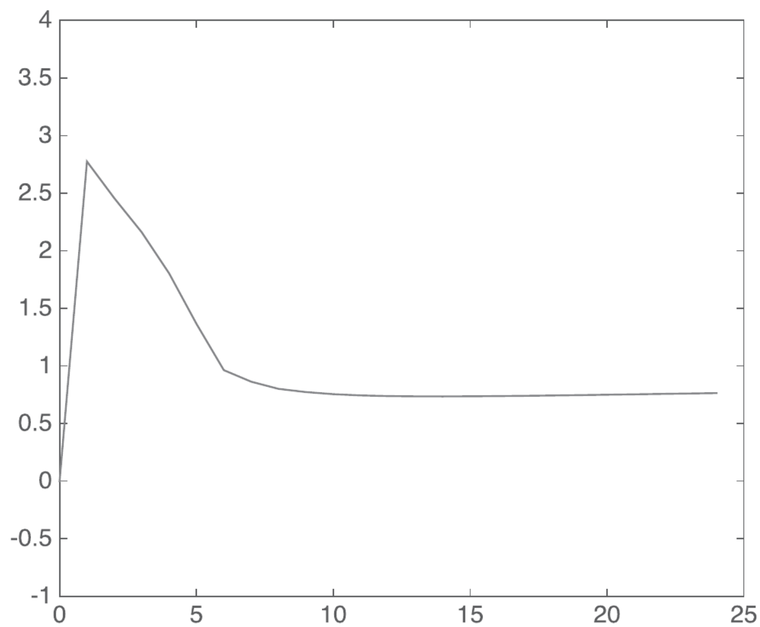
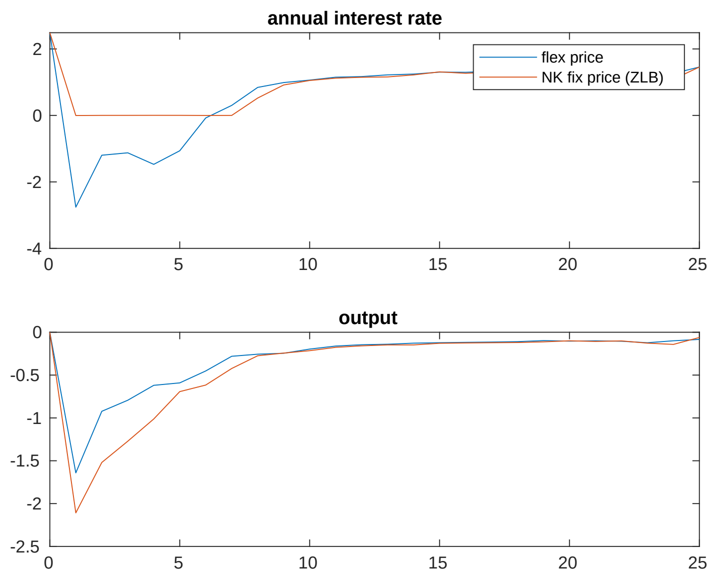


FIGURE VII

Employment Response

Percent deviations from initial steady state.

Figure 7: Figure 7 of Guerrieri & Lorenzoni (2017)



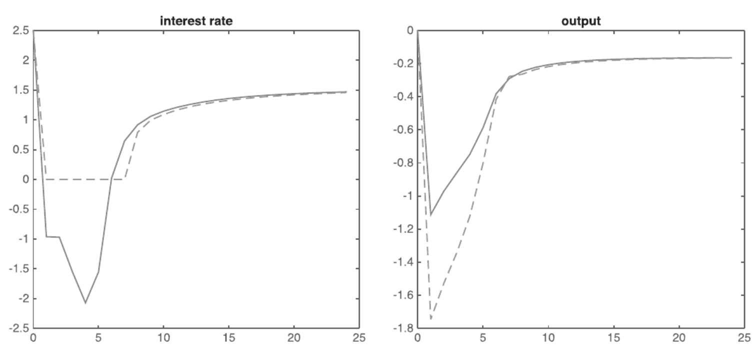
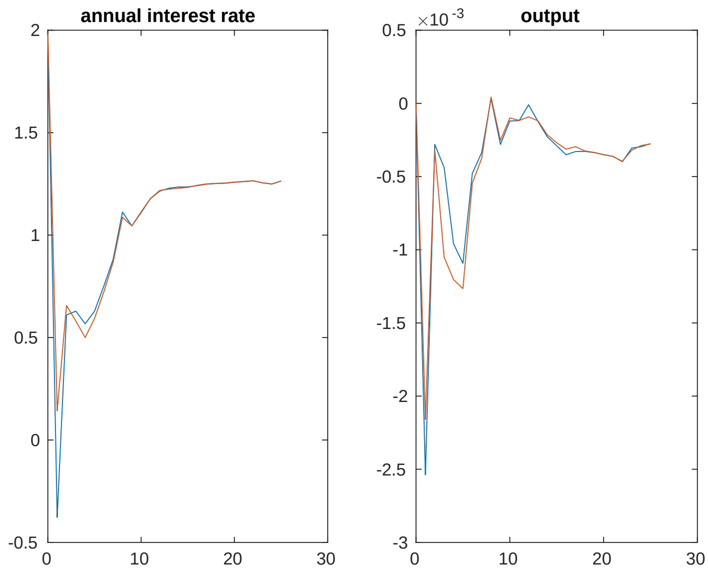


FIGURE VIII

Responses with Fixed Wages

Solid line: flexible price economy. Dashed line: economy with fixed wages. Interest rate in annual terms. Output in percent deviation from initial steady state.

Figure 8: Figure 8 of Guerrieri & Lorenzoni (2017)



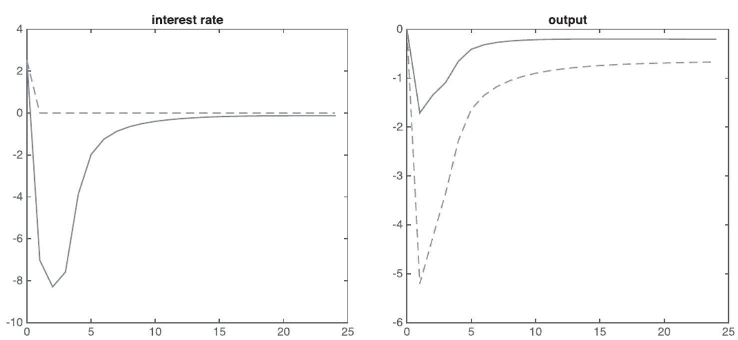
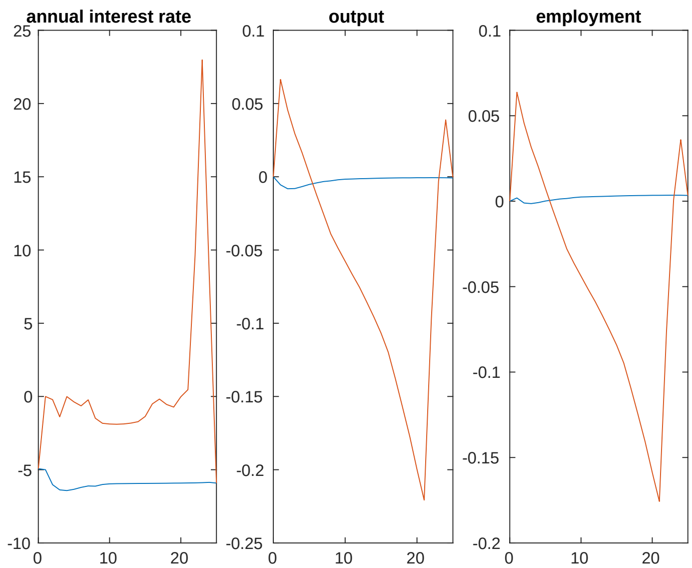


FIGURE IX

Interest Rate and Output: Median Wealth Calibration

Solid line: flexible price economy. Dashed line: economy with fixed wages. Interest rate in annual terms. Output in percent deviation from initial steady state.

Figure 9: Figure 9 of Guerrieri & Lorenzoni (2017)



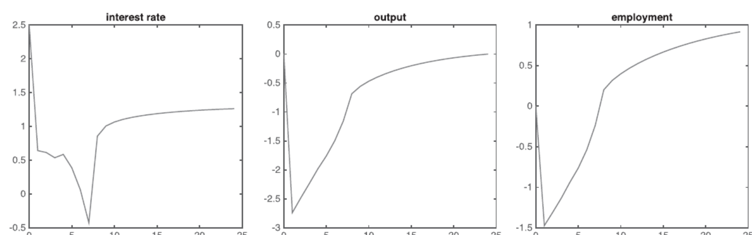
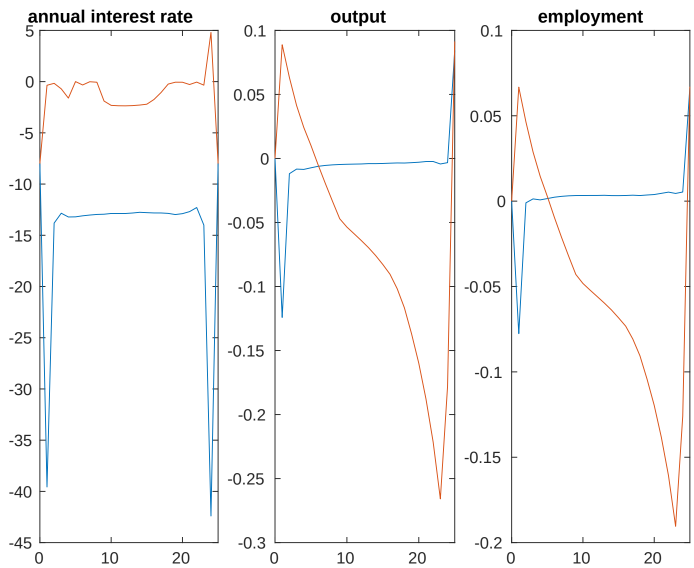


FIGURE X

Interest Rate, Output, Employment: Low ψ Calibration

Interest rate is in annual terms. Output is in percent deviation from initial steady state.

Figure 10: Figure 10 of Guerrieri & Lorenzoni (2017)



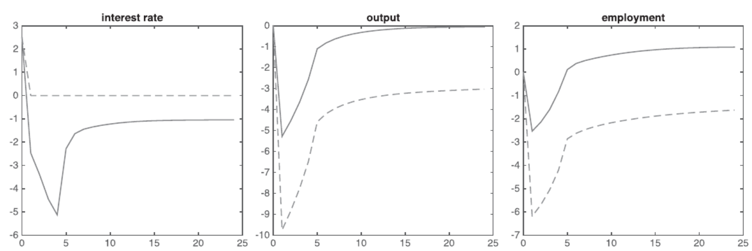
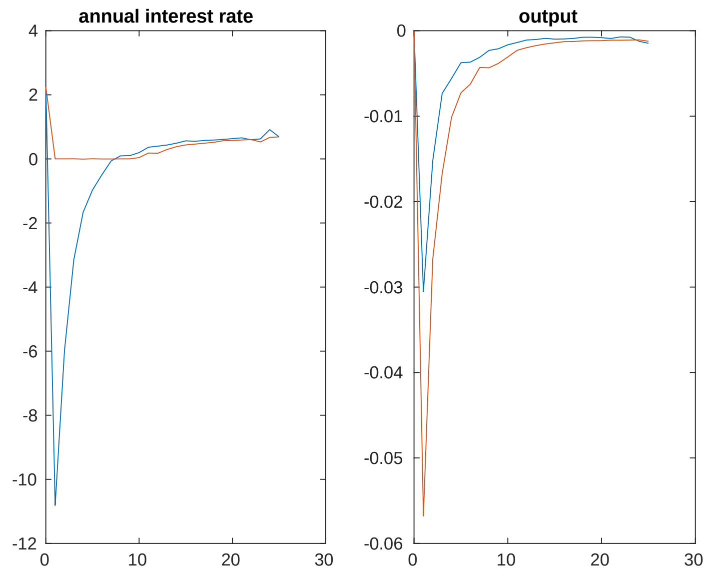


FIGURE XI

Interest Rate, Output, Employment: Median Wealth and Low ψ Calibration

Solid line: flexible price economy. Dashed line: economy with fixed wages. Interest rate is in annual terms. Output is in percent deviation from initial steady state.

Figure 11: Figure 11 of Guerrieri & Lorenzoni (2017)



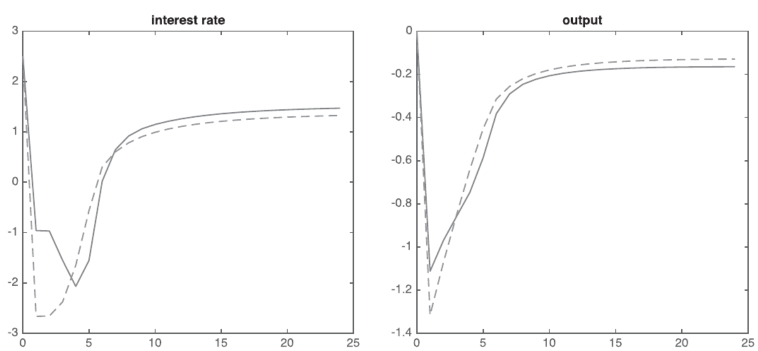
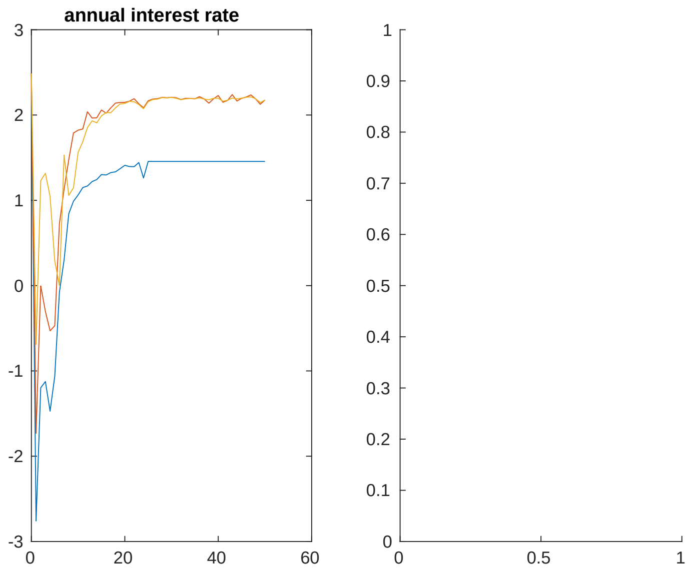


FIGURE XII

Interest Rate and Output Responses: $\gamma = 6$ Calibration

Interest rate is in annual terms. Output is in percent deviation from initial steady state.

Figure 12: Figure 12 of Guerrieri & Lorenzoni (2017)



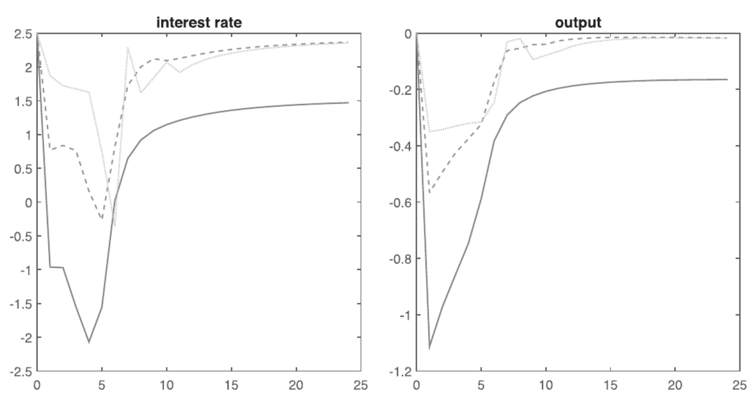
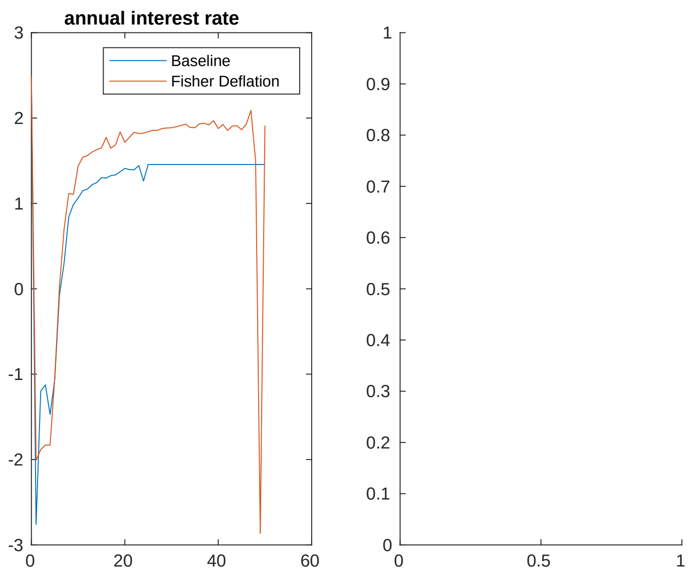


FIGURE XIII

Fiscal Policy

Solid line: baseline. Dashed line: temporary reduction in lump-sum tax. Dotted line: temporary increase in unemployment benefits. Interest rate is in annual terms. Output is in percent deviation from initial steady state.

Figure 13: Figure 13 of Guerrieri & Lorenzoni (2017)



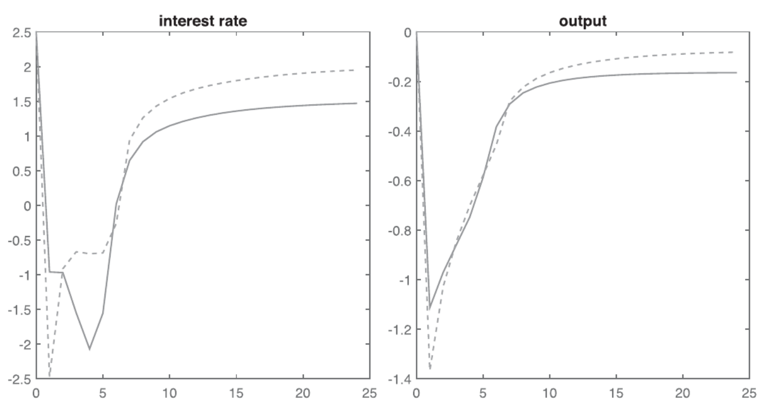


FIGURE XIV

Deflation: the Fisher Effect

Solid line: baseline. Dashed line: 10% deflation at $t = 0$. Interest rate is in annual terms. Output is in percent deviation from initial steady state.

Figure 14: Figure 14 of Guerrieri & Lorenzoni (2017)