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**Working Paper**

## US tax and spending shocks 1950-2019: SVAR overidentification with external instruments

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**APPENDIX<sup>†</sup>**  
**US Tax and Spending Shocks 1950–2019:**  
**SVAR Overidentification with External Instruments**

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<sup>†</sup>This appendix is not intended for publication.

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This appendix has four sections. Section A.1 graphs the measured, structural shocks corresponding to the two identifications discussed in section 3 of the text. Then Sections A.2 to A4 provide details on the variations in the SVAR specification that are discussed in the same sequence in section 4 of the text.

## A.1 Shocks

Section 3 noted that the historical decompositions reflect both the impact of the shocks on output and the estimated shocks themselves. Rudebusch (1998) and Sims (1998) both suggest graphing estimated structural shocks as an informative diagnostic. Figure A.1 shows the estimated structural shocks  $\{\hat{\epsilon}_{g,t}, \hat{\epsilon}_{\tau,t}, \hat{\epsilon}_{y,t}\}$  from the just-identified case (in black) and the overidentified case (in red) for the period 1951–2019. NBER-dated recessions are shown in grey. The key finding is that the estimated fiscal shocks are very similar for the two identifications.

Two other findings are worth noting. First, Figure A.1 shows a distinct pattern of counter-cyclical fiscal shocks, with positive shocks to spending and negative shocks to revenue in most recessions. Second, the shocks from the overidentified model are slightly less volatile than those from the just-identified model. Table 2 showed that in the just-identified case there is a negative correlation between  $\hat{\epsilon}_{g,t}$  and  $\hat{\epsilon}_{y,t}$ . The reduced-form shocks are linear combinations of the structural shocks:  $u_t = \Theta\epsilon_t$ . Informally, then, the just-identified estimator ascribes slightly larger variances to the structural shocks to offset this negative covariance and still fit the variances of the reduced-form residuals.

## A.2 Election Timing

Sub-section 4.1 noted that including election dummy variables in the deterministic component of the VAR did not affect the main conclusions. When we include those the three instruments remain strong, with first-stage  $F$ -statistics of 10.79, 13.98, and 101.7. The  $J$ -test statistic for the overidentifying restrictions is 3.71 with 3 degrees of freedom yielding a  $P$ -value of 0.29. Thus the covariance restrictions are not rejected at conventional levels of significance.

Figure A.2 shows the impulse response functions from this SVAR, for the effects of each fiscal shock on output and under each identification. It is very similar to Figure 3 in the text. Again the effect of the overidentification on the right-hand side of the figure is to attenuate the effects of the fiscal shocks on output. With overidentification, again the 68% confidence interval for the IRF for  $g$ -shocks includes zero. Compared to Figure 3, though, both identifications suggest slightly larger effects of the tax shock on output.

### A.3 An Additional Instrument

Sub-section 4.2 noted that we also use the innovation in the permanent component of the productivity shock (from the FRBNY DSGE model) as an additional instrument for the GDP shock. The instruments remain strong and the covariance restrictions are not rejected at conventional levels of significance. Figure A.3 shows the impulse response functions describing the effects of the two fiscal shocks on output, for the cases with and without the covariance restrictions, for comparison with Figure 3 in the text. The additional instrument narrows the confidence intervals for IRFs slightly, but the findings are very similar to those in Figure 3.

### A.4 Levels

Sub-section 4.4 summarizes the results with the SVAR in levels (with a quadratic time trend). In the just-identified model the correlation between the two fiscal shocks,  $\hat{\epsilon}_{g,t}$  and  $\hat{\epsilon}_{\tau,t}$ , is 0.44.

Figure A.4 shows the IRFs describing the effects of the two fiscal shocks on output in the just-identified case (on the left) and overidentified case (on the right) for comparison with Figure 3 in the text. The just-identified model finds that spending shocks are expansionary and tax shocks contractionary. Imposing the covariance restrictions as overidentifying moments, spending shocks become mildly contractionary (although not statistically different from zero) and the effect of tax shocks becomes attenuated. Once again the covariance restrictions also lead to narrower confidence intervals.

## References

- Rudebusch, G. (1998) Do measures of monetary policy in a VAR make sense? *International Economic Review* 39, 907–931.
- Sims, C.A. (1998) Comment on Glenn Rudebusch’s “Do measures of monetary policy in a VAR make sense?” *International Economic Review* 39, 933–941.

## Notes to Figures

### Figure A.1: Estimated Structural Shocks

Notes: The figure shows the estimated structural shocks  $\{\hat{\epsilon}_{g,t}, \hat{\epsilon}_{\tau,t}, \hat{\epsilon}_{y,t}\}$  from the just-identified case (in black) and the overidentified case (in red) for the period 1951–2019. NBER recession periods are shown in grey.

### Figure A.2: Impulse Response Functions (with election dummy variables)

Notes: The upper panel shows the effect of  $\hat{\epsilon}_g$  on  $y$  while the lower panel shows the effect of  $\hat{\epsilon}_{\tau}$  on  $y$ . The left-hand side shows the just-identified case (in black) while the right-hand side shows the overidentified case (in red). The SVAR is in growth rates so the IRFs are cumulative and level off rather than decaying to zero. Dotted lines and dashed lines show 68% and 90% asymptotic confidence intervals respectively. The vertical axis scale is the same for each  $g$ -shock and then for each  $\tau$ -shock.

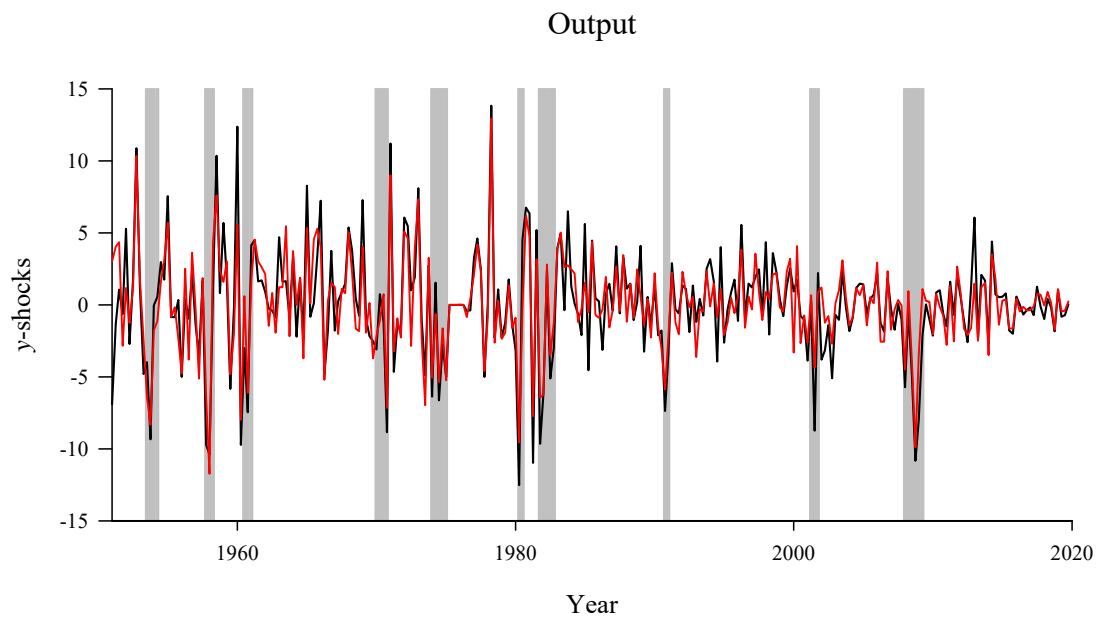
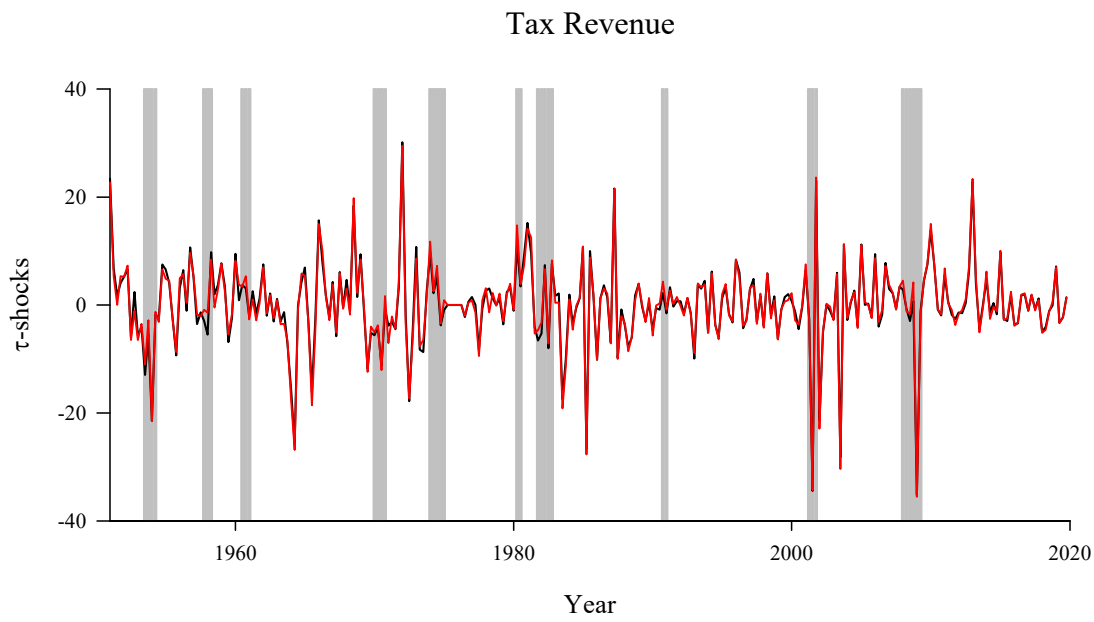
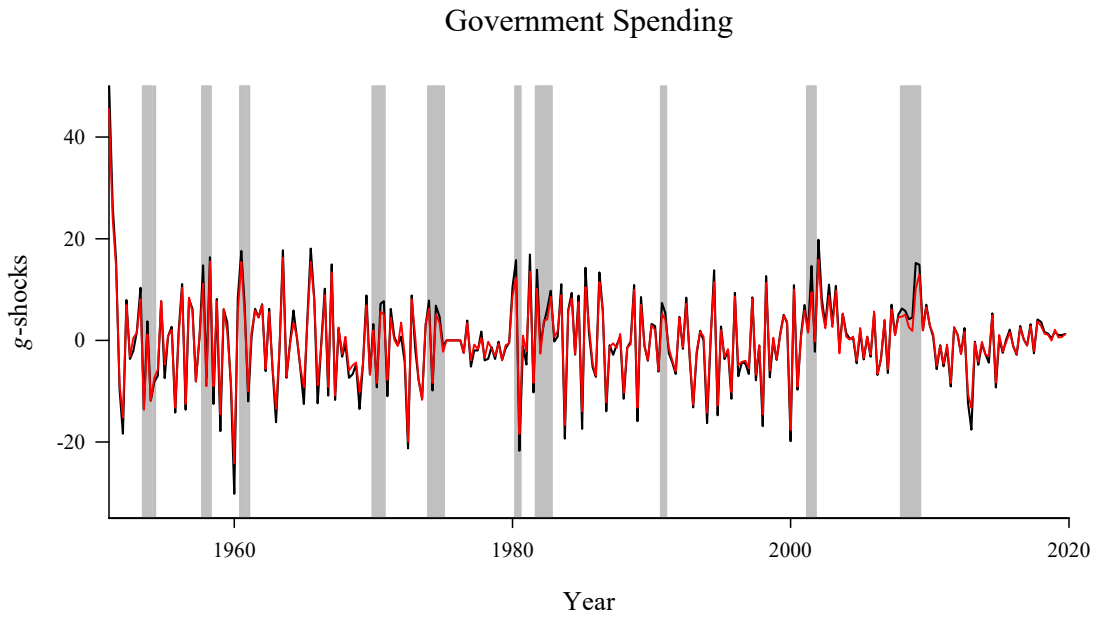
### Figure A.3: Impulse Response Functions (including two FRBNY instruments)

Notes: The upper panel shows the effect of  $\hat{\epsilon}_g$  on  $y$  while the lower panel shows the effect of  $\hat{\epsilon}_{\tau}$  on  $y$ . The left-hand side shows the IV case (in black) while the right-hand side shows the overidentified, GMM case (in red). The SVAR is in growth rates so the IRFs are cumulative and level off rather than decaying to zero. Dotted lines and dashed lines show 68% and 90% asymptotic confidence intervals respectively. The vertical axis scale is the same for each  $g$ -shock and then for each  $\tau$ -shock.

### Figure A.4: Impulse Response Functions (VAR in Levels)

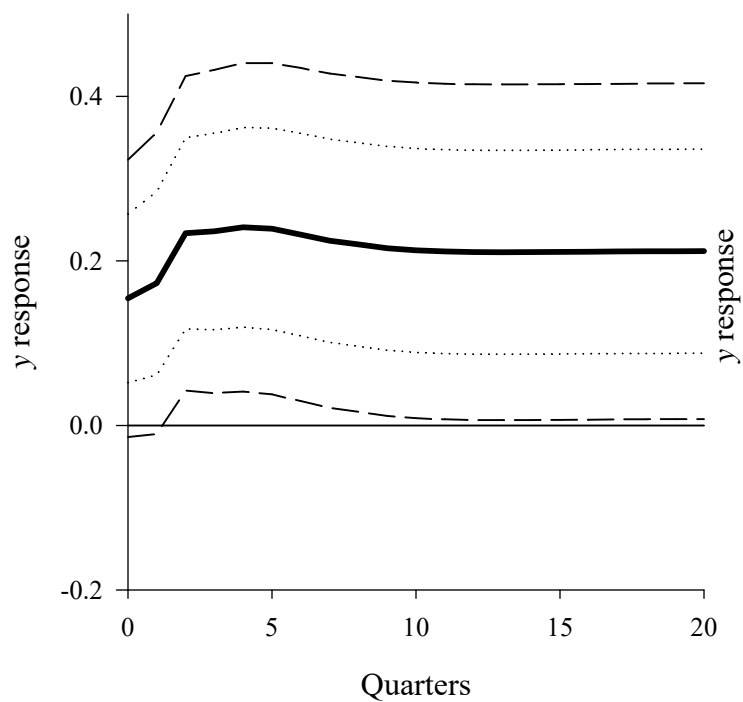
Notes: The VAR now is in levels, with a quadratic time trend included. The upper panel shows the effect of  $\hat{\epsilon}_g$  on  $y$  while the lower panel shows the effect of  $\hat{\epsilon}_{\tau}$  on  $y$ . The left-hand side shows the just-identified case (in black) while the right-hand side shows the overidentified case (in red). Dotted lines and dashed lines show 68% and 90% asymptotic confidence intervals respectively. The vertical axis scale is the same for each  $g$ -shock and then for each  $\tau$ -shock.

**Figure A.1: Estimated Structural Shocks**

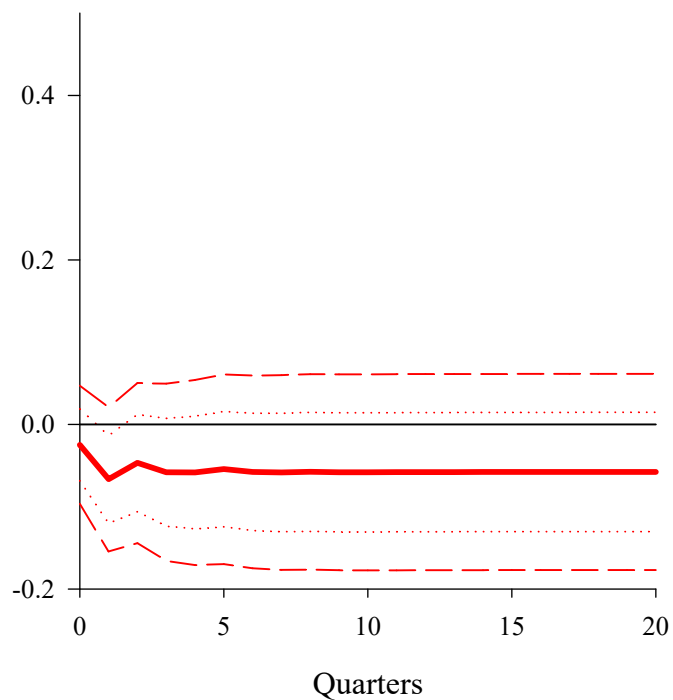


**Figure A.2: Impulse Response Functions  
(with election dummy variables)**

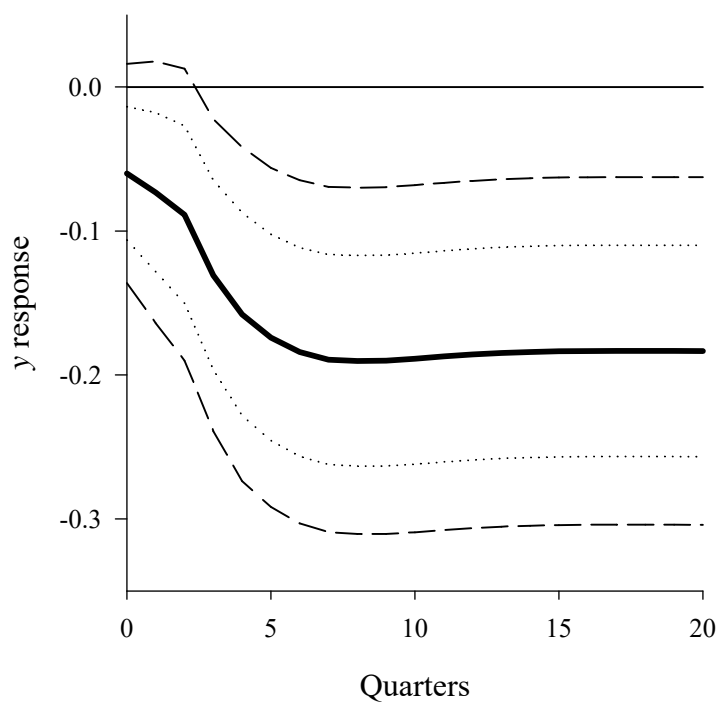
Just-identified  $g$ -shock



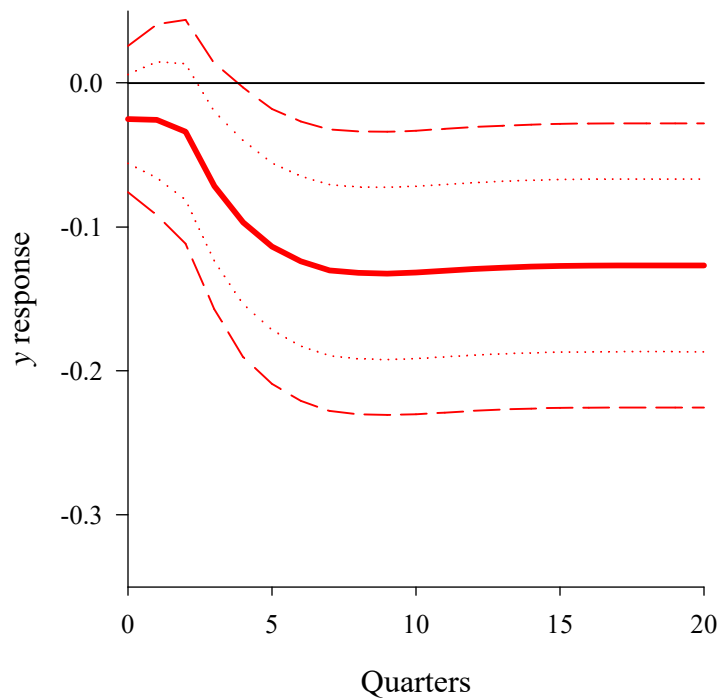
Overidentified  $g$ -shock



Just-identified  $\tau$ -shock

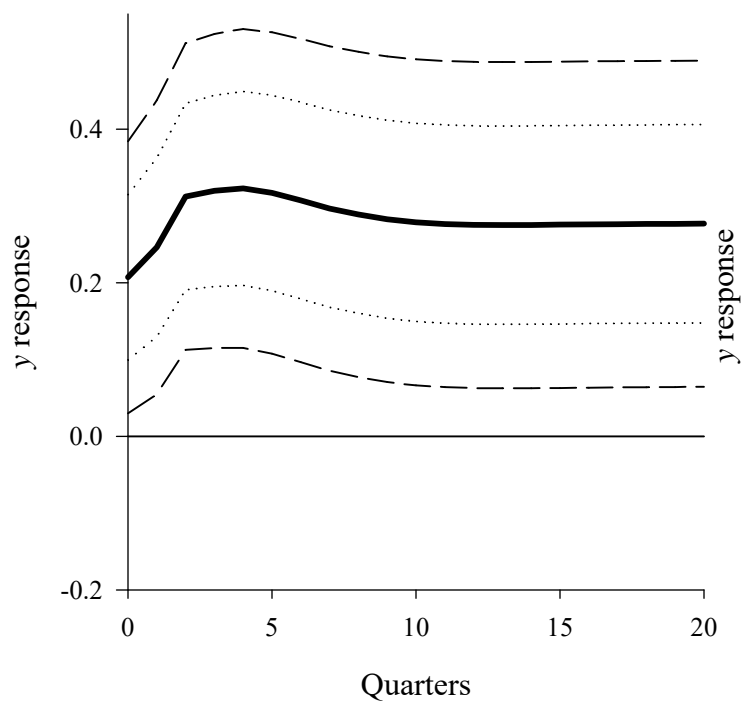


Overidentified  $\tau$ -shock

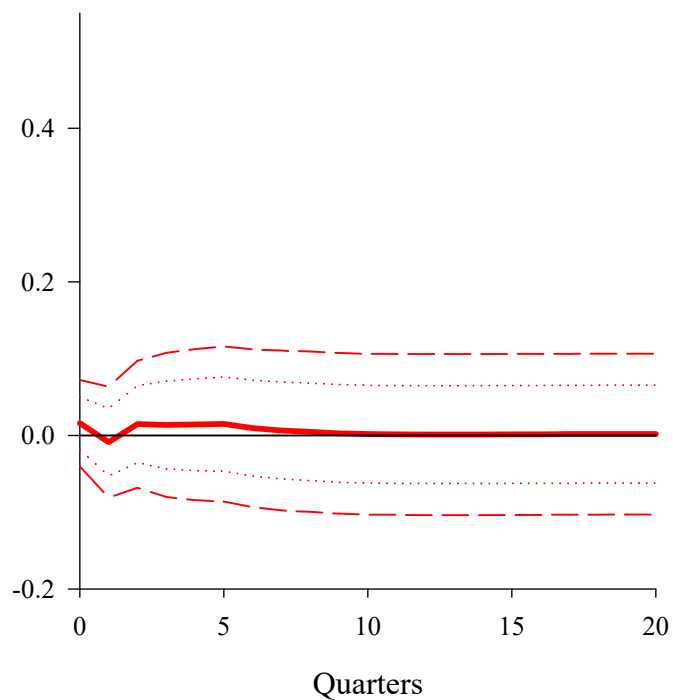


**Figure A.3: Impulse Response Functions  
(including two FRBNY instruments)**

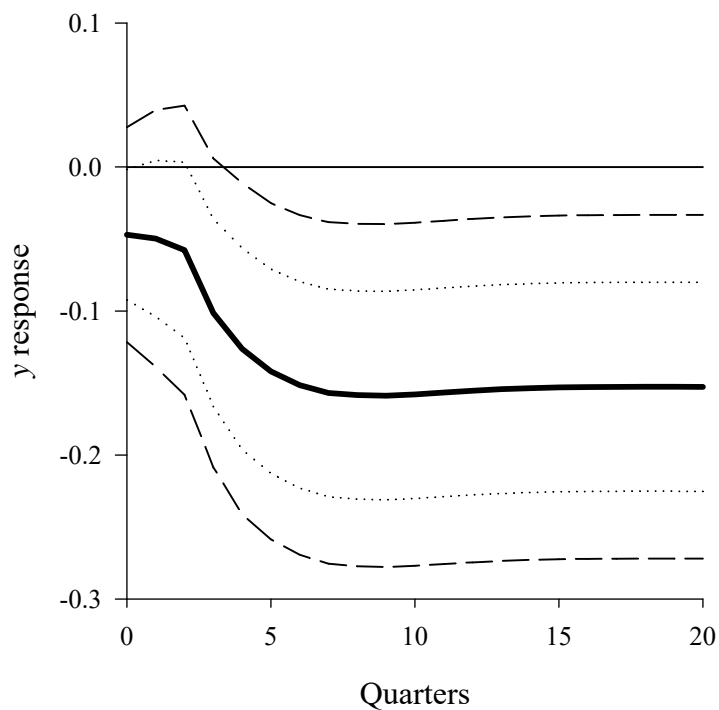
Just-identified g-shock



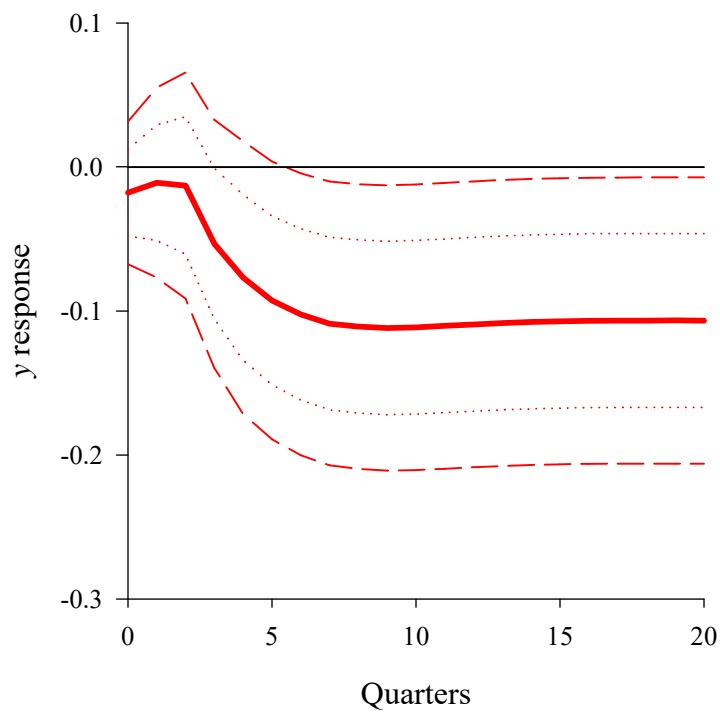
Overidentified g-shock



Just-identified  $\tau$ -shock



Overidentified  $\tau$ -shock



**Figure A.4: Impulse Response Functions  
(VAR in Levels)**

