Applied Macroeconomics (Local Projection Method – LPM)
Assignment[1] (Due date : August 21, 2020)

Anil Shrestha, PhD Student, Hiroshima University

1. **In this assignment, you are required to estimate "fiscal multipliers" in G7 countries by using the SVAR model and local projection method.**
2. **First, for G7 countries, please collect quarterly data on real GDP, government consumption, tax revenues, private consumption, private investment, and the short-term interest rate.[2]**

   Seasonally adjusted quarterly data of GDP, government consumption, private consumption, investment[3], and short-term interest rate are obtained from OECD's statistics portal[4]. For tax revenue quarterly data, IMF's International Finance Statistics (IFS)[5] dataset is used. Nominal quarterly data expressed in domestic currency are converted in US dollar using quarterly exchange rates which later converted into real terms using quarterly GDP deflator. Variables are expressed in millions.

3. **Second, by using the SVAR model, please estimate fiscal multiplier (please note that what you need to estimate is not output responses to fiscal policy shock, but fiscal multipliers). When you estimate model, please try two specifications: (i) GDP, gov. consumption, and tax revenues; (ii) all variables.**

   Since we are using panel data, panel vector autoregressive (VAR) model is estimated using *Stata* as elaborated by Abrigo and Love (2016). All the variables, except short-term interest rate, are converted into log form before using in the model.

   First, a panel VAR model (model i) is estimated with GDP, govt. consumption, and tax revenues in log form.

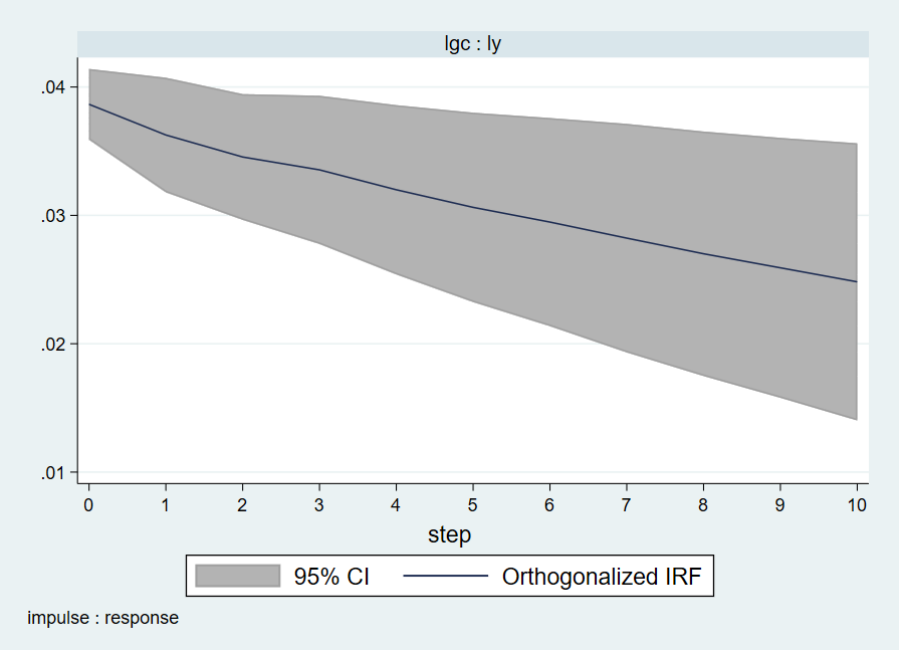

Figure 1 Orthogonalized response of log(GDP) to shock in log(Govt. Consumption) – model (i)

[1] *Jupyter* notebook is available at bit.ly/2RK7ad6 with replicable code and results.
[2] Compiled data and downloaded datasets are available at bit.ly/32KNvAb and bit.ly/2RGAdyb
[3] Private Investment quarterly data could not be found, and Gross Capital Formation quarterly data is used as investment data.
[4] https://stats.oecd.org/
[5] https://data.imf.org/ifs

Second, another panel VAR model (model ii) is estimated with all available variable in log form.

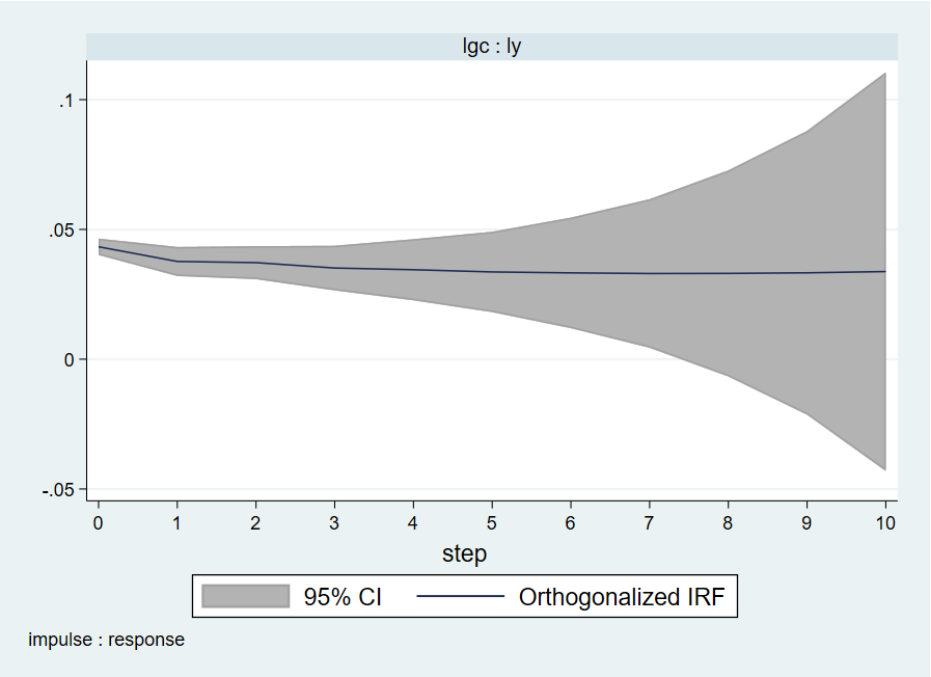

Figure 2 Orthogonalized response of log(GDP) to shock in log(Govt. Consumption) – model (ii)

Here, we obtain elasticity ($\frac{\partial \log(GDP)}{\partial \log(Govt.Consumption)}$) estimates for each horizon from these impulse responses of model (i) and (ii). Now, we can calculate fiscal multipliers by multiplying these elasticity estimates by *ad hoc* conversion factor i.e. average ratio of GDP to government consumption.[6]

Table 1 Fiscal multiplier using conversion factor

Horizon	Elasticities (Δlog(Y)/Δlog(G))		Conversion Factor, average (Y/G)	Fiscal Multiplier (ΔY/ΔG)	
	Model (i)	Model (ii)		Model (i)	Model (ii)
0	0.039*	0.043*	5.383	0.208*	0.233*
1	0.036*	0.038*	5.383	0.195*	0.203*
2	0.035*	0.037*	5.383	0.186*	0.200*
3	0.034*	0.035*	5.383	0.181*	0.189*
4	0.032*	0.034*	5.383	0.172*	0.186*
5	0.031*	0.034*	5.383	0.165*	0.181*
6	0.029*	0.033*	5.383	0.159*	0.179*
7	0.028*	0.033*	5.383	0.152*	0.178*
8	0.027*	0.033	5.383	0.145*	0.178
9	0.026*	0.033	5.383	0.140*	0.179
10	0.025*	0.034	5.383	0.134*	0.182

** significant at 95% level of significance*

[6] The use of *ad hoc* conversion factor – average of (Y/G) – for fiscal multiplier calculation is mentioned by Ramey (2019). He also critiques the use of such conversion factor as it is prone to bias due to possibility of significant variation in the ratio. Nevertheless, in this assignment, for the shake of simplicity and in fact, presence of small variation in Y/G ratio (minimum 4.06 and maximum 7.18 with average 5.38), the *ad hoc* conversion factor is used to arrive at fiscal multiplier numbers.

4. **Third, by using the identified shock via the SVAR model, estimate the fiscal multipliers by using the local projection method.**

The following steps are followed to identify the shocks in government consumption.

a. SVAR is estimated for each country with variable order of log(Govt. Consumption), log(GDP), and log(tax).

b. Optimal lag(s) length is selected based on Schwarz Criterion (SC).

c. Residuals are then extracted from the first equation of the SVAR system.

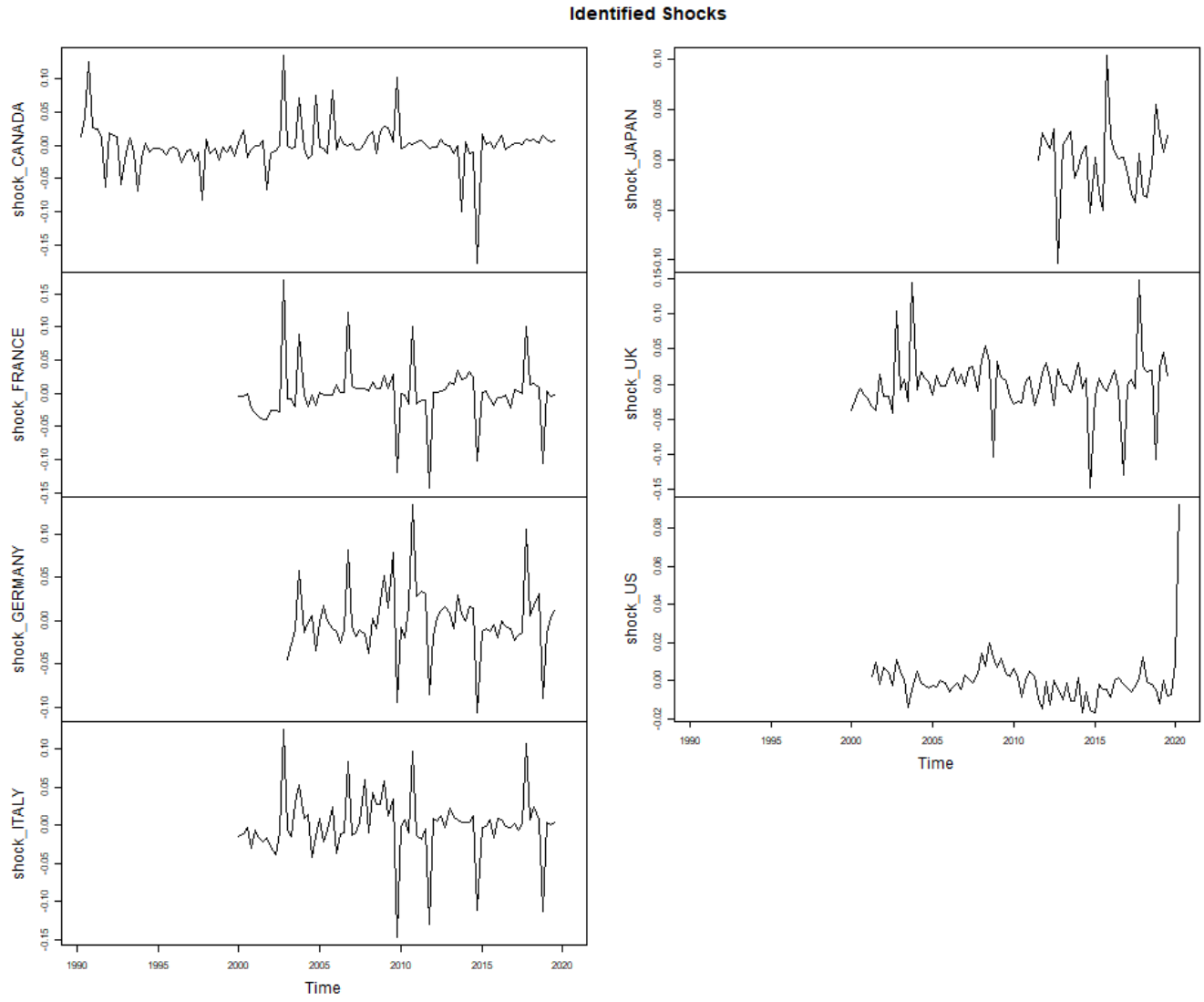

Figure 3 Identified Government Consumption shocks for G7 nations

Now, the following model is used for local projection method.

$$Y_{i,t+h} = \beta^h \, shock_{i,t} + \theta^h X_{i,t} + \alpha_i^h + \gamma_i^h + \varepsilon_{i,t}^h$$

Where, Y is log of GDP, shock is identified government consumption shock, X is vector of control variables (i.e. tax, private consumption, investment, and short-term interest rate), α is the country fixed effect, γ is the time fixed-effects, and ε is residuals.

The following impulse responses are obtained, and fiscal multipliers are calculated using ad hoc conversion factor (Y/G ratio).

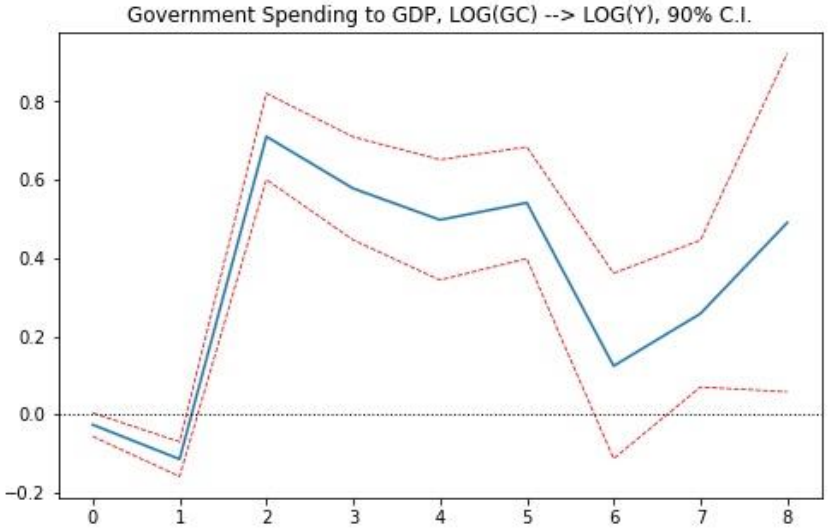

Figure 4 response of log(GDP) to shock in log(Govt. Consumption) – Local Projection Method

Table 2 Fiscal multiplier – Local Projection Method

Horizon	Elasticities (Δlog(Y)/Δlog(G))	Conversion Factor, average (Y/G)	Fiscal Multiplier (ΔY/ΔG)
0	-0.026	5.383	-0.141
1	-0.114*	5.383	-0.614*
2	0.711*	5.383	3.827*
3	0.578*	5.383	3.112*
4	0.498*	5.383	2.679*
5	0.541*	5.383	2.914*
6	0.124	5.383	0.668
7	0.258*	5.383	1.388*
8	0.491*	5.383	2.641*

** significant at 90% level of significance*

5. Fourth, by using the local projection method, please estimate the state dependent fiscal multipliers. As for a business cycle indicator, please use the trend (moving average) of real GDP growth rate.

The following model is used for local projection method.

$$Y_{i,t+h} = \beta_1^h \, G(z_{i,t}) \, shock_{i,t} + \beta_2^h \left(1 - G\left(z_{i,t}\right)\right) shock_{i,t} + \theta^h X_{i,t} + \alpha_i^h + \gamma_i^h + \varepsilon_{i,t}^h$$

Where, Y is log of GDP, shock is identified government consumption shock, X is vector of control variables (i.e. tax, private consumption, investment, and short-term interest rate), α is the country fixed effect, γ is the time fixed-effects, and ε is residuals.

$G(z_{i,t})$ is smooth transition function, given by $G\left(z_{i,t}\right) = \frac{\exp(-\delta\, z_{i,t})}{1+\exp(-\delta\, z_{i,t})}$, $\delta > 0$ where δ is set to 1.5 and z is normalized quarterly moving average GDP growth rate[7].

By using coefficient estimates β_1^h , β_2^h and their respective standard errors, the following state dependent impulse responses are obtained, and fiscal multipliers are calculated using ad hoc conversion factor (Y/G ratio).

[7] 5 quarter's moving average is used.

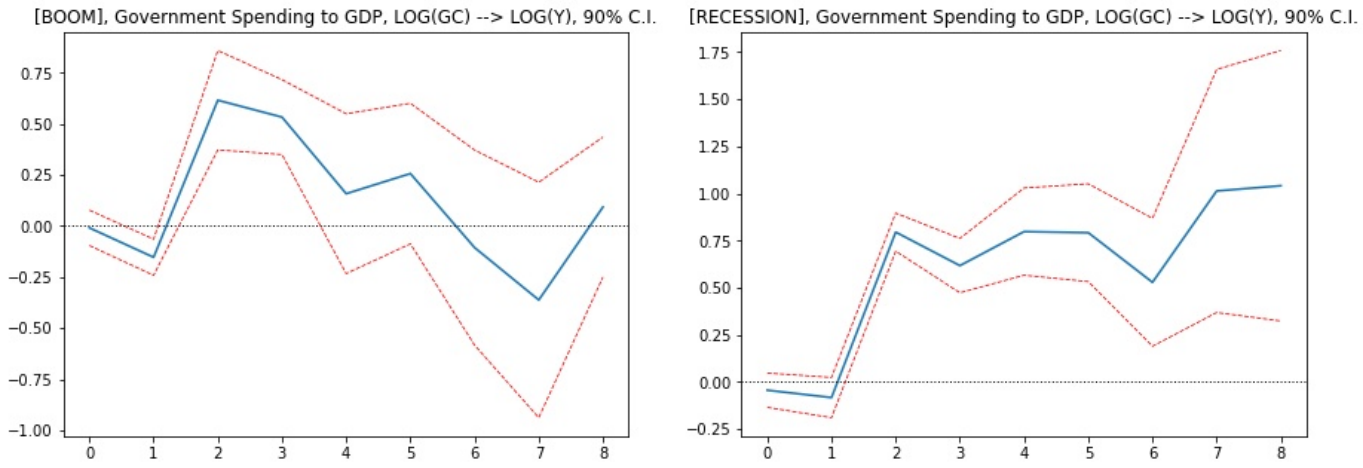

Figure 5 State-dependent response of log(GDP) to shock in log(Govt. Consumption) – Local Projection Method

Table 3 State dependent fiscal multiplier – Local Projection Method

Horizon	Elasticities (Δlog(Y)/Δlog(G))		Conversion Factor, average (Y/G)	Fiscal Multiplier (ΔY/ΔG)	
	BOOM	RECESSION		BOOM	RECESSION
0	-0.009	-0.043	5.383	-0.051	-0.232
1	-0.153*	-0.082	5.383	-0.826*	-0.442
2	0.615*	0.796*	5.383	3.313*	4.283*
3	0.533*	0.618*	5.383	2.868*	3.326*
4	0.158	0.798*	5.383	0.850	4.297*
5	0.256	0.792*	5.383	1.380	4.266*
6	-0.106	0.529*	5.383	-0.571	2.849*
7	-0.362	1.014*	5.383	-1.951	5.459*
8	0.093	1.042*	5.383	0.499	5.607*

** significant at 90% level of significance*

The above figure of impulse responses and fiscal multiplier estimates clearly show that fiscal multipliers in recession are relatively higher and persistent over long horizon than in boom.

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References:

Abrigo, M. R., & Love, I. (2016). Estimation of panel vector autoregression in Stata. *The Stata Journal*, *16*(3), 778-804.

Ramey, V. A. (2019). Ten years after the financial crisis: What have we learned from the renaissance in fiscal research?. *Journal of Economic Perspectives*, *33*(2), 89-114.