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a.) Equilibrium condition $\ln S_t = \ln D_t$

$$\beta_{10} + \beta_{11} \ln P_{Dt} + \beta_{12} \ln P_{X2t} + \beta_{13} \ln P_{X3t} + \beta_{14} \ln P_{X4t} + \varepsilon_{1t} = \beta_{20} + \beta_{21} \ln P_{Dt} + \beta_{22} \ln GDP_t + \varepsilon_{2t}$$

$$(\beta_{11} - \beta_{21}) \ln P_{Dt} = \beta_{20} + \beta_{10} - \beta_{12} \ln P_{X2t} - \beta_{13} \ln P_{X3t} + \beta_{22} \ln GDP_t + \varepsilon_{2t} - \varepsilon_{1t}$$

$$\ln P_{Dt} = \frac{\beta_{20} + \beta_{10}}{\beta_{11} - \beta_{21}} - \frac{\beta_{12} \ln P_{X2t}}{\beta_{11} - \beta_{21}} - \frac{\beta_{13} \ln P_{X3t}}{\beta_{11} - \beta_{21}} + \frac{\beta_{22} \ln GDP_t}{\beta_{11} - \beta_{21}} + \frac{\varepsilon_{2t} - \varepsilon_{1t}}{\beta_{11} - \beta_{21}}$$

$$= \pi_0 + \pi_1 \ln GDP_t - \pi_2 \ln P_{X2t} - \pi_3 \ln P_{X3t} - \pi \ln P_{X4t} + w_t$$

Substitute $\ln P_{Dt}$ in Demand and Supply ;

$$\ln S_t = \pi_{10} + \pi_{11} \ln GDP_t + \pi_{12} \ln P_{X2t} + \pi_{13} \ln P_{X3t} + \pi_{14} \ln P_{X4t} + w_{1t}$$

$$\ln D_t = \pi_{20} + \pi_{21} \ln GDP_t + \pi_{22} \ln P_{X2t} + \pi_{23} \ln P_{X3t} + \pi_{24} \ln P_{X4t} + w_{2t}$$

Prediction :

$$\widehat{\ln S_t} = \underset{(5.310)}{24.657} + \underset{(0.191)}{0.344} \ln GDP_{1t} - \underset{(0.152)}{0.4503} \ln P_{X2t} - \underset{(0.278)}{0.924} \ln P_{X3t} - \underset{(0.422)}{0.388} \ln P_{X4t}$$

$$\widehat{\ln D_t} = \underset{(5.4)}{27.186} + \underset{(.195)}{0.187} \ln GDP_{1t} - \underset{(.154)}{0.487} \ln P_{X2t} - \underset{(.283)}{0.722} \ln P_{X3t} - \underset{(.422)}{0.598} \ln P_{X4t}$$

b.) $$\widehat{\ln S_t} = \underset{(.572)}{29.533} + \underset{(.072)}{0.131} \ln P_{Dt} - \underset{(.022)}{0.529} \ln P_{X2t} - \underset{(.04)}{0.761} \ln P_{X3t} - \underset{(.054)}{0.779} \ln P_{X4t}$$

$$\widehat{\ln D_t} = \underset{(4.482)}{19.190} - \underset{(0.347)}{1.287} \ln P_{Dt} + \underset{(0.105)}{0.7061} \ln GDP$$

c.) OLS :

$$\widehat{\ln S_t} = 41.495 - 1.11 \ln P_{Dt} - 0.411 \ln P_{X2t} - 0.942 \ln P_{X3t} - 0.521 \ln P_{X4t}$$

$$\widehat{\ln D_t} = 31.036 - 2.181 \ln P_{Dt} + 0.598 \ln GDP_t$$

2SLS :

$$\widehat{\ln S_t} = 18.6 + 2.106 \ln P_{Dt} - 0.928 \ln P_{X2t} - 1.122 \ln P_{X3t} - 1.429 \ln P_{X4t}.$$

$$\widehat{\ln D_t} = 35.985 - 2.57 \ln P_{Dt} + 0.52 \ln GDP_t$$

3SLS :

$$\widehat{\ln S_t} = 17.379 + 2.813 \ln P_{Dt} - 0.844 \ln P_{x2t} - 1.460 \ln P_{x3t} - 1.010 \ln P_{x4t}$$

$$\widehat{\ln D_t} = 35.935 - 2.574 \ln P_{Dt} + 0.521 \ln GDP_t$$

I3SLS

$$\widehat{\ln S_t} = 17.379 + 2.815 \ln P_{Dt} - 0.844 \ln P_{x2t} - 1.960 \ln P_{x3t} - 1.01 \ln P_{x4t}$$

$$\widehat{\ln D_t} = 35.935 - 2.57 \ln P_{Dt} + 0.521 \ln GDP_t$$

Hausman test H_0: No endogeneity H_a: endogeneity.

$\widehat{\ln S_t}$: p-value = $0.5659 > 0.05$

H_0 is not rejected at .05 level, there is no endogeneity.

$\widehat{\ln D_t}$: p-value = $0.3667 > 0.05$

H_0 is not rejected at .05 level, there is no endogeneity.

Concerning on asymptotic property, 3SLS might be the most appropriated; because using 3SLS, the estimators will be more asymptotically efficient than using 2SLS. But 3SLS might cause the specification error.

β_{21} ⇒ If domestic price increases by 1%, on average, domestic demand is predicted to be decreased by β_{21} %.

β_{22} ⇒ If GDP increases by 1%, on average, domestic demand is predicted to be increased by β_{22} %.

d.) OLS :

$$\ln Q_t = 40.102 - 1.854 \ln P_{Dt} - 0.386 \ln P_{x2} - 0.698 \ln P_{x3} - 0.361 \ln P_{x4}.$$

$$\ln Q_t = 31.036 - 2.181 \ln P_{Dt} + 0.598 \ln GDP_t$$

2SLS :

$$\ln Q_t = 24.956 + 0.995 \ln P_{Dt} - 0.591 \ln P_{x2t} - 0.799 \ln P_{x3t} - 0.961 \ln P_{x4t}.$$

$$\ln Q_t = 35.935 - 2.574 \ln P_{Dt} + 0.521 \ln GDP_t.$$

3SLS :

$$\ln Q_t = 24.411 + 0.984 \ln P_{Dt} - 0.605 \ln P_{x2t} - 0.8391 \ln P_{x3t} - 0.911 \ln P_{x4t}.$$

$$\ln Q_t = 35.935 - 2.574 \ln P_{Dt} + 0.521 \ln GDP_t.$$

e.) We use the quantity demanded as transaction quantity since the collected data shows that demand always less than supply. It make sense that price of inputs would affect the quantity demanded by consumers.

Using demand as supply may cause specification error (measurement error), which would make estimators biased.