* Assume log-linear supply-demand system.

$$y_{it} = \varepsilon^S p_{it} + \eta z_{it} + \Gamma^S x_{it} + v_{it}^S \quad \text{(supply)}$$

$$y_{it} = \varepsilon^D p_{it} + \gamma z_{it} + \Gamma^D x_{it} + v_{it}^D \quad \text{(demand)}$$

* can similarly write down reduced-form.

$$\begin{bmatrix} y_{it} \\ p_{it} \end{bmatrix} = \begin{bmatrix} \pi_{zy} \\ \pi_{zp} \end{bmatrix} z_{it} + \begin{bmatrix} \Pi_{xy} \\ \Pi_{xp} \end{bmatrix} x_{it} + \xi_{it}.$$

* without further restrictions.

$$\underbrace{\begin{bmatrix} \pi_{zy} \\ \pi_{zp} \end{bmatrix}}_{\text{two reduced-form estimates}} = \underbrace{\begin{bmatrix} \dfrac{\varepsilon^S \gamma - \varepsilon^D \eta}{\varepsilon^S - \varepsilon^D} \\ \dfrac{\gamma - \eta}{\varepsilon^S - \varepsilon^D} \end{bmatrix}}_{\text{four unknown structual parameters}}$$

NOT identified.

* What additional exclusion restriction do we need?

- interestingly if z_{it} happens to represent an "ad valorem" tax that enters log price linearly. then it works!

  → SER (standard exclusion restriction) $\eta = 0$, i.e. tax is levied on demand side.

  → RER (ramsey exclusion restriction) $z_{it} = \log(1+\tau_{it})$, $\gamma = \varepsilon^D$, i.e. demand only depends on price after tax.

- with these assumptions

we can write

$$\begin{bmatrix} \pi_{zy} \\ \\ \pi_{zp} \end{bmatrix} = \begin{bmatrix} \dfrac{\varepsilon^S \varepsilon^D}{\varepsilon^S - \varepsilon^D} \\ \\ \dfrac{\varepsilon^D}{\varepsilon^S - \varepsilon^D} \end{bmatrix} \qquad \text{Identified}$$

obviously, we will still need.

The relevance condition for IVs

$\rightarrow \pi_{zp} \neq 0$ (variation in tax rate does affect pre-tax price, o.w. entire incidence is on demand side)

$\pi_{zp} \neq -1$ (after-tax price is not independent of tax rate, o.w. entire incidence is on supply side).

- Estimation follows standard. 2SLS.