ECON 815

Technology vs. Demand Shocks

Winter 2015

What does really drive BCs?

Some correlations for Canada (1/1981-3/2013):

- corr(GDP, Hours) = 0.696
- corr(GDP, Prod) = 0.491
- corr(Prod, Hours) = -0.285

So hours move countercyclical relative to productivity.

In the RBC model, we need very high intertemporal elasticity of substitution, so that the income effect dominates the substitution effect.

1) What shocks are responsible for cycles?

2) How can we identify these from the data?

VAR Analysis

Consider the reduced-form VAR:

$$\mathbf{y}_t = \mu + \mathbf{\Gamma}_1 \mathbf{y}_{t-1} + \cdots + \mathbf{\Gamma}_p \mathbf{y}_{t-p} + \nu_t$$

For theoretical exposition, we can always stack vectors of longer lags to only consider a first-order VAR

$$\begin{bmatrix} \mathbf{y}_t \\ \mathbf{y}_{t-1} \end{bmatrix} = \begin{bmatrix} \mu \\ \mathbf{0} \end{bmatrix} + \begin{bmatrix} \mathbf{\Gamma}_1 & \mathbf{\Gamma}_2 \\ \mathbf{I} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \mathbf{y}_{t-1} \\ \mathbf{y}_{t-2} \end{bmatrix} + \begin{bmatrix} \nu_t \\ \mathbf{0} \end{bmatrix}$$

or, with redefined variables

$$\mathbf{y}_t = \mu + \mathbf{\Gamma} \mathbf{y}_{t-1} + \nu_t$$

We are interested again either in IRFs or in estimating (long-run) correlations between variables.

For that purpose, we can transform the VAR into its MA representation (presuming that $\mathbf{\Gamma}$ is stable)

$$\begin{aligned} \mathbf{y}_t &= \mu + \mathbf{\Gamma}\mathbf{y}_{t-1} + \nu_t \\ &= \mu + \mathbf{\Gamma}(L)\mathbf{y}_t + \nu_t \\ &= [\mathbf{I} - \mathbf{\Gamma}(L)]^{-1}(\mu + \nu_t) \\ &= \bar{\mathbf{y}} + \sum_{i=0}^{\infty} \mathbf{\Gamma}^i \nu_{t-i} \end{aligned}$$

Interpretation:

- we can use the $\mathbf{\Gamma}^i$ matrices to figure out IRFs
- element is given by $\gamma_{ml}(i)$
- deviation of $y_{m,t+i}$ from its mean to a one-time "shock" in ν_{lt}

One can use OLS to (point) estimate $\Gamma(L)$. Use bootstrapping to obtain standard errors.

<u>Problem:</u> How do we interpret the coefficients $\Gamma(L)$ and shocks ν_{lt}?

The Identification Problem

We start with the MA representation of a VAR:

$$\mathbf{y}_t = \mathbf{F}(L)\nu_t$$

where ν_t has mean zero, is serial uncorrelated and has $E[\nu_t, \nu_t'] = \mathbf{\Sigma}$.

We want to consider a structure (economic model) A_0 such that

$$\mathbf{y}_t = \mathbf{F}(L)\mathbf{A}_0\mathbf{A}_0^{-1}\nu_t = \mathbf{A}(L)\epsilon_t$$

where $\mathbf{A}(L) = \mathbf{F}(L)\mathbf{A}_0$ and $\epsilon_t = \mathbf{A_0}^{-1}\nu_t$.

The lead matrix of $\mathbf{A}(L)$ is $\mathbf{A}_0$ and gives the contemporaneous interactions among the variables.

Identifying a VAR is equivalent of choosing a unique $\mathbf{A}_0$.

The associated ϵ_t are interpreted as structural shocks.

Restrictions

The choice of $\mathbf{A}_0$ can be seen as restricting the covariance matrix of the *structural* shocks.

Why? $E[\epsilon_t \epsilon_t'] = \mathbf{A}_0^{-1} \mathbf{\Sigma} \mathbf{A}_0^{-1\prime}$

We need n^2 restrictions if there are n variables.

We normalize the units of the shocks (n) and assume they are uncorrelated ($n(n-1)/2$) which yields

$$\mathbf{A}_0^{-1} \mathbf{\Sigma} \mathbf{A}_0^{-1\prime} = \mathbf{I}_n$$

How do we find $n(n-1)/2$ more restrictions?

- recursive structure and ordering (Cholesky decomposition)
- restrictons on contemporaneous variables from theory (SVAR)
- long-run neutrality restrictions (Blanchard and Quah)

Sims (1980):

Order the variables such that variables higher in the order are determined before variable lower in the order.

Shocks to higher variables influence lower variables, but not the other way around.

SVAR:

Impose ad-hoc restrictions from economic theory on the contemporaneous restrictions among variables.

Blanchard and Quah (1989):

Use long-run neutrality restrictions from economic theory.

If the jth shock does not influence the ith variable, we have $a_{ij}(1) = 0$ for $\mathbf{A}(L)$.

With only long-run restrictions, we can order the VAR to obtain $\mathbf{A}(1)$ to be lower triangular.

Application – Productivity and Hours for CAN

Model – VAR in hours n_t and (labour) productivity z_t

We log first-difference productivity and hours to get stationarity

- $\Delta z_t = \log z_t - \log z_{t-1}$
- $\Delta n_t = \log n_t - \log n_{t-1}$

Reduced-form VAR:

$$\begin{pmatrix} \Delta z_t \\ \Delta n_t \end{pmatrix} = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{pmatrix} \Delta z_{t-1} \\ \Delta n_{t-1} \end{pmatrix} + \begin{pmatrix} \nu_{1t} \\ \nu_{2t} \end{pmatrix}$$

We can estimate this VAR and use it for forecasting. To go further, we need to make identification assumptions.

Recursiveness

Reduced form VAR:

- lag of 1
- coefficient matrix

$$\mathbf{\Gamma} = \begin{bmatrix} 0.0686 & 0.16273 \\ 0.4527 & 0.6087 \end{bmatrix}$$

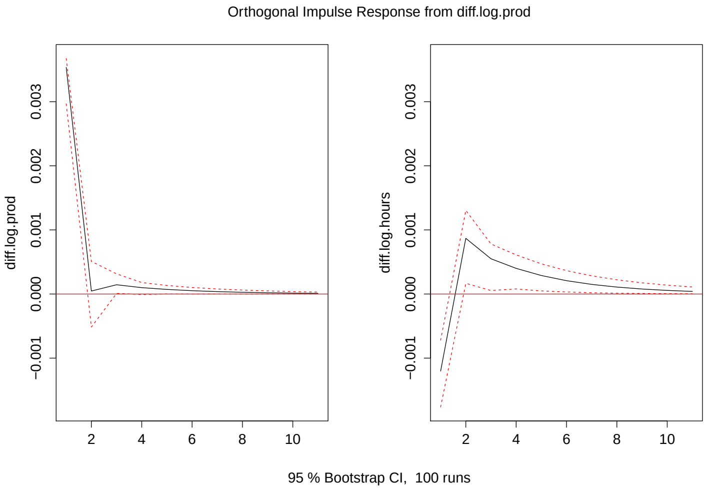
- Identifying restriction

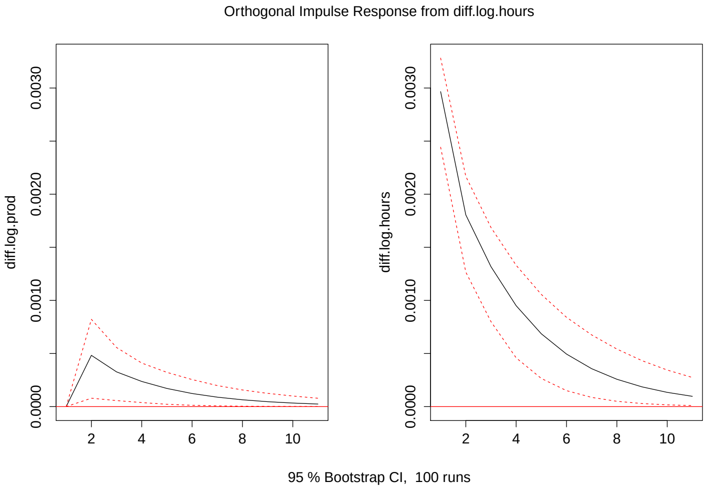
$$\mathbf{A_0}^{-1} = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

We assume that shocks are orthogonal to each other and normalized to 1.

We interpret ϵ_{1t} as a technology shock and ϵ_{2t} as everything else (what?) that has no direct contemporaneous impact whatsoever on productivity.

IRFs – Recursive VAR




Orthogonal Impulse Response from diff.log.hours
diff.log.prod
diff.log.hours
0.0000
0.0010
0.0020
0.0030
2
4
6
8
10
95 % Bootstrap CI, 100 runs

Long-run Restrictions a la Gali, AER (1993)

We would like to call some shocks *supply or technology* shocks and others *demand* shocks and obtain correlations *conditional* on these shocks.

Assumptions:

1) Shocks are orthogonal and normalized (3 restrictions).

2) (Long-run restriction) Productivity is influenced in the long-run only by technology shocks.

This means that we have the following MA representation

$$\begin{pmatrix} \Delta z_t \\ \Delta n_t \end{pmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) \\ C_{21}(L) & C_{22}(L) \end{bmatrix} \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} = \mathbf{C}(L)\epsilon_t$$

with restriction $C_{12}(1) = 0$ or $\mathbf{C}(1)$ being lower triangular.

Interpretation – Sticky Price Model

Shocks

- technology

$$\log z_t = \log z_{t-1} + \eta_t$$

- demand or policy shock

$$\log M_t^s = \log M_{t-1}^s + \chi_t$$

With technology shock, firms will not adjust output since real balances do not change and with fixed prices demand is constant.

$\Longrightarrow$ *negative* correlation between hours and productivity.

With demand shock, real balances rise for one period since prices are fixed and, thus demand and output increase.

$\Longrightarrow$ *positive* correlation between hours and productivity

Evidence from Canadian Data

Step 1 – Reduced form VAR from above

Step 2 – Structural VAR as in Gali (1999):

- restrict long-run impact matrix $\mathbf{C}(1)$ to be lower triangular

$$\mathbf{C}(1) = \begin{bmatrix} 0.0044 & 0 \\ 0.0051 & 0.0082 \end{bmatrix}$$

- contemporaneous impact matrix for MA representation

$$\mathbf{B}^{-1} = \begin{bmatrix} 0.0033 & -0.0013 \\ 0.0000 & 0.0032 \end{bmatrix}$$

- calculated conditional correlations from MA representation
  - $corr(\Delta z_t, \Delta n_t|1) = 0.128$
  - $corr(\Delta z_t, \Delta n_t|2) = -0.579$