

Sectoral Shocks, Long-run Persistence and the Business Cycle

Innovazioni Settoriali, Persistenza di Lungo Periodo ed il Ciclo degli Affari

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Riassunto: Nel presente lavoro è proposta una metodologia per valutare gli effetti di innovazioni settoriali sul prodotto sia aggregato sia settoriale attraverso delle misure statistiche dell'importanza di tali innovazioni sul ciclo degli affari e nel lungo periodo. Tali misure sono illustrate attraverso un'applicazione su dati settoriali statunitensi.

Keywords: Sectoral shocks, Cointegration, Common cycles, Spectral analysis.

1. Introduction

Sectoral shocks play an important role in explaining output fluctuations. In real business cycle (RBC) theory Long and Plosser (1983) investigated how idiosyncratic technology shocks are responsible for persistence and comovements in output series. Engle and Issler (1995) provide an extension of this model to account for the stylized facts that sectoral outputs series have unit roots and are cointegrated. If the shocks are not common across sectors, comovements among sectors are unlikely. In general, both common and sector-specific shocks are important for studying output growth dynamics. Despite these findings in the theoretical literature, most of the empirical literature have focused only on examining the degree of short- and long-run comovement present in output series (among others, Engle and Issler, 1995) and on the measure of the persistence of aggregate shocks (e.g., Pesaran *et al.*, 1993). It could be interesting, however, to analyze the effects of sectoral shocks on output fluctuations.

The aim of this paper is to build a statistical measure to evaluate the effects of sectoral shocks on both aggregate and sectoral output at the business cycle frequencies and in the long-run. In Section 2, we isolate within a Vector Error Correction Model (VECM) the components of a set of cointegrated time series of sectoral outputs explained by sector-specific shock. In Section 3, we show how to derive the spectra of these components and provide a simple statistic which measures the contribution of each shock to the spectral mass of a variable at a given frequency band. Finally, Section 4 illustrates all these concepts with an application to US sectoral output series.

2. Sectoral shocks

Let y_t be a n -vector of sectoral outputs y_{it} , $y_t = (y_{1t}, \dots, y_{nt})'$, and the aggregate output Y_t be

$Y_t = \sum_{i=1}^I w_i y_{i,t} \equiv w' y_t$, where the w 's are sector weights, $w = (w_1, \dots, w_n)'$.

We assume that series y_t are I(1) with cointegration rank r that admits the following VECM representation

$$\Gamma(L)(1-L) = \Phi D_t + \alpha \beta' y_{t-1} + \varepsilon_t, \quad (1)$$

where D_t are the deterministic terms, $\Gamma(L) = I_n - \sum_{i=1}^{p-1} \Gamma_i L^i$ and $\varepsilon_t \sim N_n(0, \Sigma)$, $\Sigma = \{\sigma_{i,j}, i, j = 1, \dots, n\}$.

Series y_t admit also the following Wold representation

$$\Delta y_t = \Theta D_t + C(L) \varepsilon_t, \quad (2)$$

where $\Theta D_t = C(L) \Phi D_t$, and $C(L) = I_n + \sum_{i=1}^{\infty} C_i L^i$ is such that $\sum_{j=1}^{\infty} j |C_j| < \infty$. Note that (see e.g. Johansen, 1996) $C(1) = \beta_{\perp} (\alpha'_{\perp} \Gamma(1) \alpha_{\perp})^{-1} \alpha'_{\perp}$.

Definition: let ξ_t^i be the components of y_t that are explained by the i -th sectoral shock where $(1-L)\xi_t^i = C_i(L)\varepsilon_{it}$ and $C_i(L) = C(L)(\sigma_{i1}, \dots, \sigma_{in})' \sigma_{ii}^{-1}$.

Note also that $C_i(1) = C(1)(\sigma_{i1}, \dots, \sigma_{in})' \sigma_{ii}^{-1}$.

3. Measuring the Effects of Sectoral Shocks

Let us define the spectral density matrix of the process y_t as follows

$$F(\omega) = \frac{1}{2\pi} C^*(z) \Sigma C^*(z^{-1})' \quad (3)$$

where $(1-L)C^*(L) = C(L)$, and $z = \exp(-\omega\sqrt{-1})$ for $\omega \in (0, \pi]$.¹ In order to compute $F(\omega)$ for $\omega \in (0, \pi]$, the matrices $C^*(z)$'s may be derived from the VECM parameters (1) through the relation $C^*(z) = [\Gamma(z)(1-z) - \alpha\beta'z]^{-1}$. We are now in the position to introduce our measures of the contributions of the sectoral shocks to the cyclical fluctuations of both aggregate and sectoral output at a given frequency band.

Definition: (Measures of the BC effects of the i -th sectoral shock on aggregate output at a given frequency band). Let $R_i(\omega_0, \omega_1)$ indicate the proportions of the spectral mass of Y_t at the frequency band $[\omega_0, \omega_1]$ which are due to i -th sectoral shock, where $0 < \omega_0 < \omega_1 \leq \pi$. Then we have

$$R_i(\omega_0, \omega_1) = \int_{\omega_0}^{\omega_1} w' F_i(\omega) w d\omega \bigg/ \int_{\omega_0}^{\omega_1} w' F(\omega) w d\omega. \quad (4)$$

¹ Strictly speaking, $F(\omega)$ is a pseudo-spectral density matrix since series y_t have unit roots, so it is unbounded at frequency zero. In the sequel we will use the term spectral density matrix to refer to both I(1) and I(0) processes.

for $i=1, \dots, n$, where $F_i(\omega) = \frac{\sigma_{ii}}{2\pi} C_i^*(z) C_i^*(z^{-1})'$ and $(1-L)C_i^*(L) = C_i(L)$.

Definition: (Measures of the BC effects of the i -th sectoral shock on the j -th sectoral output). Let $R_{i,j}(\omega_0, \omega_1)$ indicate the proportions of the spectral mass of y_{jt} at the frequency band $[\omega_0, \omega_1]$ which are due to j -th sectoral shock, where $0 < \omega_0 < \omega_1 \leq \pi$. Then we have

$$R_{i,j}(\omega_0, \omega_1) = \int_{\omega_0}^{\omega_1} e_j' F_i(\omega) e_j d\omega \bigg/ \int_{\omega_0}^{\omega_1} e_j' F(\omega) e_j d\omega \quad (5)$$

where e_j is an n -vector with unity as its j th element and zeroes elsewhere.

Remark: for any n -vector $e \neq 0$ we have

$$\frac{e' F_i(\omega) e}{e' F(\omega) e} = \frac{e' C_i(z) \sigma_{ii} C_i(z^{-1})' e}{e' C(z) \Sigma C(z^{-1})' e} \quad (6)$$

because the factor $(1-z)$ cancels out.

Definition: (Measures of the long-run effects of the i -th sectoral shock on aggregate output). Let $R_i(0)$ indicate the proportions of the spectral mass of ΔY_t at zero frequency which are due to i -th sectoral shock. Then we have

$$R_i(0) = w' C_i(1) \sigma_{ii} C_i(1)' w / w' C(1) \Sigma C(1)' w. \quad (7)$$

Definition: (Measures of the long-run effects of the i -th sectoral shock on the j -th sectoral output). Let $R_{i,j}(0)$ indicate the proportions of the spectral mass of y_{jt} at zero frequency which are due to j -th sectoral shock. Then we have

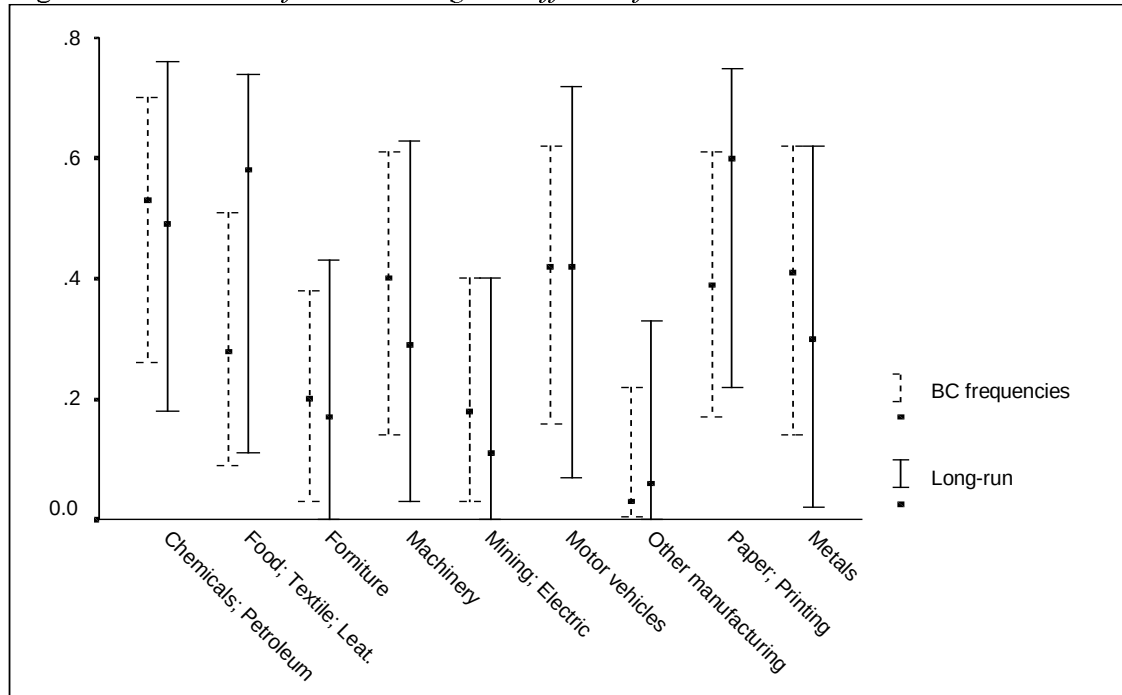
$$R_{i,j}(0) = e_j' C_i(1) \sigma_{ii} C_i(1)' e_j / e_j' C(1) \Sigma C(1)' e_j. \quad (8)$$

4. Empirical Example

In this section we apply the proposed measures to US sectoral output data. In particular, we use the logarithms of the industrial production index of nine sectors for the period 1975:Q1 through 2002:Q4. The usual information criteria, namely Akaike, Schwarz and Hannan-Quinn, select for these data a VAR(3). A LM test for no residual autocorrelation up to order five is not rejected at the 10% significance level. We use the Johansen's trace statistics to determine the number of cointegrating vectors. A deterministic trend is included in the long-run to capture the differences among the average growth rates of the various sectoral outputs. We do not reject the presence of three cointegrating vectors, i.e. sectoral outputs are driven by six common permanent shocks. We fix at $r=3$ the number of cointegrating vectors and we continue with the SCCF analysis (Vahid and Engle, 1993). It emerges that we cannot exclude the presence of four SCCF vectors. AIC also indicates $s=4$. We conclude that there are five common transmission mechanisms of the sector-specific shocks through the industrial sector. We

then derive from the estimated VECM parameters the spectra of each variable and its components at the frequencies corresponding to 8-32 quarter periods². In Figure 1 we report the measures of the cyclical and long-run effects of sectoral shocks on aggregate output, along with their bootstrap 95% confidence limits.

Figure 1: Measures of BC and long-run effects of sectoral shocks



We see that sectors that do not account for the fluctuations of aggregate output at the BC frequencies also do not in the long-run. Instead, the Paper and Printing sector and the Food, textile and Leather account for relatively small amount of output fluctuations at the BC frequencies, instead are more important for the long-run.

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² In particular, these spectra are computed for $\omega_k = \pi/16((199-k)/199) + \pi/4(k/199)$ and $k=0,1,\dots,199$.