Economics Letters 100 (2008) 392–395

Contents lists available at ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/econbase

Technology shocks, structural breaks and the effects on the business cycle☆

Vincenzo Atella [a], Marco Centoni [b], Gianluca Cubadda [a,*]

[a] CEIS & Dipartimento SEFEMEQ, Università di Roma "Tor Vergata", Roma, Italy
[b] Dipartimento SEGES, Università del Molise, Campobasso, Italy

ARTICLE INFO

Article history:
Received 9 February 2007
Received in revised form 8 February 2008
Accepted 6 March 2008
Available online 15 March 2008

Keywords:
Business cycle
Technology shocks
Structural breaks

JEL classification:
C32
E32

ABSTRACT

It is shown that time-series of US productivity and hours are apparently affected by a structural break in the late 60s. Moreover, the importance of technology shocks over the business cycle has sharply decreased after the break.

1. Introduction

Determining what the driving forces are of aggregate fluctuations is a highly debated research topic in macroeconomics. While real business cycle (RBC) models predict that technological shocks generate most of business cycles (see, e.g., Kydland and Prescott, 1982), new-Keynesian theorists focus on the relevance of nominal shocks. The second viewpoint has recently gained empirical consensus on the basis of an influential paper by Galí (1999), whose main finding is to reject a key prediction of the RBC paradigm, namely the existence of positive comovements between output, employment and productivity in response to technology shocks.

We contribute to this literature in two ways. First, we question that the data generating process (DGP) of labor productivity and hours is stable over time, as implicitly assumed in most of previous analyses. In particular, we test for structural changes with unknown break dates in a vector auto-regressive (VAR) model of these variables. Second, we resort to a measure of the sources of the business cycles via a parametric spectral analysis as proposed by Centoni and Cubadda (2003). Since this measure is directly derived from the structural VAR parameters, it is possible to evaluate its sample variability through bootstrap techniques. This peculiarity is appealing when evaluating changes in the determinants of the business cycle across sub-periods.

The paper is organized as follows. After shortly reviewing the Galí's (1999) approach in Section 2, in Section 3 we apply the parameter stability test by Bai et al. (1998) to the Galí's (1999, 2004) bivariate VAR model , and find a single break in the late sixties. In Section 4, we link this break to a decrease in the short-run response of monetary policy to technology shocks. In Section 5, we show that the conditional correlation between hours and productivity on technology shocks changed over time. In Section 6 we document that the break had a strong impact on the importance of sources of cyclical fluctuations.

2. The Galí's approach

The Galí's (1999) key identifying assumption is that labor productivity is permanently affected only by technology innovations. Formally, let n_t, y_t, and $x_t \equiv y_t - n_t$ denote, respectively, the logarithms of hours, output, and labor productivity. The bivariate time series $u_t \equiv (\Delta x_t, \Delta n_t)'$ is supposed to be generated by the following stationary stochastic process

$$u_t = \delta + C(L)\varepsilon_t, \tag{1}$$

where δ is a 2-vector of constant terms, $\varepsilon_t \equiv (\varepsilon_t^z, \varepsilon_t^m)'$ are i.i.d. $N_2(0, I_2)$, ε_t^z and ε_t^m denote, respectively, technology and non-technology shocks, $C(L) = \sum_{i=0}^{\infty} C_i L^i$ is such that $\sum_{j=1}^{\infty} j|C_j| < \infty$ and $C(1)$ is a lower-triangular matrix.

☆ We wish to thank Bertrand Candelon, Luigi Guiso, Fabrizio Mattesini, Francesco Nucci, and Pasquale Scaramozzino, as well as an anonymous referee, for useful comments on a preliminary draft of this paper. Gianluca Cubadda gratefully acknowledges financial support from University of Tor Vergata 2005–2006 grants. The usual disclaimers apply.

* Corresponding author. Dipartimento SEFEMEQ, Università di Roma "Tor Vergata", Via Columbia, 2, 00133 Roma, Italy. Tel.: +39 06 72595847; fax: +39 06 2040219.
E-mail address: gianluca.cubadda@uniroma2.it (G. Cubadda).

0165-1765/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.econlet.2008.03.011

Table 1
Structural break tests

Sample period	Break date	Test statistic	Asymptotic p-value	Bootstrap p-value
1947:1–2004:4	1968:2	32.36	0.071	0.014
1947:1–1968:2	1952:2	12.39	0.997	0.853
1968:3–2004:4	1985:1	19.78	0.758	0.365

Note: p-values are obtained by 5000 bootstrap replications.

Hence, only technology shocks ε_t^z have permanent effects on labor productivity.

For statistical inference, we assume that series u_t admits the following VAR(p) representation:

$$A(L)u_t = \mu + \nu_t, \quad t = 1, \dots, T, \tag{2}$$

where μ is a 2-vector of constant terms, ν_t are i.i.d. $N_2(0, \Omega)$, and $A(L) = I_n - \sum_{i=1}^{p} A_i L^i$ is such that the roots of det $[A(L)]$ are outside the unite circle.

Since the structural shocks ε_t are linked to reduced form VAR innovations ν_t by the relation $\nu_t = S\varepsilon_t$, where $S = A(1)C(1)$, and $C(1) = \text{chol}[A(1)^{-1}\Omega(A(1)^{-1})']$, consistent estimates of the coefficients of model (1) are obtained from the estimated parameters of model (2) through the relation $C(L) = A(L)^{-1}S$.

3. Testing for structural breaks

The previous empirical model is specified assuming that the DGP of the time series $\{u_t, t=1,\dots,T\}$ is constant over time. As this assumption is rather questionable, we test for the presence of structural breaks in model (2).

Let first test for one break at time $\tau = \pi T$, where $\pi \in (0, 1)$, and its date τ is unknown. Model (2) is then generalized by the following sub-sample VAR models:

$$A^-(L)u_t = \mu^- + \nu_t, \quad t = 1, \dots, \tau, \tag{3}$$

$$A^+(L)u_t = \mu^+ + \nu_t, \quad t = \tau + 1, \dots T, \tag{4}$$

where μ^- and μ^+ are 2-vectors of constant terms, and $A^-(L) = I_n - \sum_{i=1}^{p} A_i^- L^i$ and $A^+(L) = I_n \sum_{i=1}^{p} A_i^+ L^i$ are such that the roots of det $[A^-(L)]$ and det $[A^+(L)]$ are outside the unite circle.

Under the null hypothesis that the model is stable over time we have

$$H_0 : [A^-(L) = A^+(L)] \cap [\mu^- = \mu^+]. \tag{5}$$

Since the break date is unknown, we must resort to a testing procedure that allows us to treat τ as a parameter to be estimated. A standard solution is to perform a sequence of Chow tests, and date the break when the test statistic takes the largest value. Formally, the test statistic is the following:

$$\text{LR}\left(\hat{\tau}\right) = \sup_{\tau \in [\underline{\tau}, \overline{\tau}]} \text{LR}(\tau), \tag{6}$$

where LR(τ) is the likelihood ratio test for the null hypothesis (5) having fixed the break date at time τ, and $[\underline{\tau}, \overline{\tau}]$ is the trimming region, which is usually set to $[0.15T, 0.85T]$.

Table 2
Estimates and confidence intervals of conditional variances

Variance	Sample: 1947:1–1967:1	Sample: 1969:3–2004:4
Var($\Delta y_t \mid z$)	7.253 [2.557,15.228]	1.357 [0.669,3.979]
Var($\Delta y_t \mid m$)	15.031 [7.783,21.693]	10.871 [7.598,13.022]
Var($\Delta n_t \mid z$)	2.512 [1.283,5.630]	1.638 [0.612,3.401]
Var($\Delta n_t \mid m$)	9.116 [5.556,11.890]	5.011 [3.235,6.539]

Table 3
Structural break test over 1979:3–1982:3

Sample period	Trimming region	Break date	Test statistic	Asymptotic p-value	Bootstrap p-value
1969:3–2004:4	1979.3–1982.3	1981:2	18.06	0.400	0.163

Since the asymptotic distribution, which was provided by Bai et al. (1998), is often a poor approximation of the exact distribution of parameter stability tests when applied to multivariate dynamic models (Candelon and Lütkepohl, 2001), we also use a bootstrap procedure to evaluate the significance of the test statistics (6).[1]

Finally, we investigate the existence of multiple breaks by the Bai and Perron (1998) sequential method. Having found a significant break at date τ, we test for an additional break in each of the segments $(1, \tau)$, $(\tau+1, T)$. If no additional significant break is found, the procedure stops. Otherwise, test again for the presence of another break in each pair of adjacent segments that are separated by an additional significant break. The rationale of this testing procedure is that the fraction τ/T will be consistently estimated for the break that allows for the greatest reduction in the sum of residuals, even if several breaks exist.

We use U.S. quarterly seasonally adjusted indexes of labor productivity and hours of the business sector for the period 1947:1–2004:4. Having fixed $p=3$ according to the AIC, the testing results, reported in Table 1, favor the existence of a single break in the second quarter of 1968, thus supporting previous empirical findings in studies of the postwar productivity slowdown (Bai et al., 1998; Candelon and Cubadda, 2006).

We check the possibility that the detected break is associated exclusively with a change in the constant term by means of a likelihood-ratio test for the restrictions $A^-(L) = A^+(L)$ in the segmented VAR models (3)–(4). The resulting $\chi^2(12)$ statistic is equal to 24.22, which is significant at the 5% level using both the asymptotic and bootstrap test.

In order to separate more clearly the two regimes, the rest of the analysis excludes the 95% asymptotic confidence interval of the significant break date, namely 1967:2–1969:2. Hence, we focus on the two sub-samples 1947:1–1967:1 and 1969:3–2004:4.

4. Changes in the conditional variances

The evidence of a structural break in the DGP calls for an economic interpretation. Hence, we refer to the Galí's (1999) stylized model, which admits the following solutions for output and hours:

$$\Delta y_t = \Delta \xi_t + \gamma \eta_t + (1 - \gamma)\eta_{t-1}, \tag{7}$$

$$n_t = \frac{1}{\varphi}\xi_t + \frac{\gamma - 1}{\varphi}\eta_t, \tag{8}$$

where $\xi_t = \sigma_\xi \varepsilon_t^m$, $\eta_t = \sigma_\eta \varepsilon_t^z$, $\sigma_\eta > 0$, $\sigma_\xi > 0$, $\varphi > 0$ denotes the short-run return to labor, and $\gamma = \partial(\Delta m_t)/\partial \eta_t > 0$ measures the short-run response of monetary policy to technology shocks.

[1] This procedure is based on three steps. First, estimate model (2) and store the estimated parameters and the residuals $\hat{\nu}_t$. Second, sample with replacement from $\hat{\nu}_t$ 5000 times, and take the estimated parameters in Eq. (2) to rebuild the data that are used to bootstrap $LR(\hat{t})$. Third, compute the bootstrap p-value as the percentage of the simulated statistics that are larger than the actual statistic.