1984

A Cross-Country Study of the Symmetry of Business Cycles

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A Cross-Country Study of the Symmetry of Business Cycles

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Recently developed testing procedures have led to renewed interest in the empirical evaluation of the hypothesis that business cycle contractions tend to be sharper and shorter than expansions. Evidence presented by Neftci (1984) and Falk (1984) suggests that, in the United States, cycles in unemployment and real GNP behave in ways that are consistent with the asymmetry hypothesis. This paper looks at time series pertaining to aggregate production in Canada and four West European countries. It does not find additional support for the asymmetry hypothesis.

Disciplines
Business Administration, Management, and Operations | Economic Theory | International Business | International Economics

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A Cross-Country Study of
the Symmetry of Business Cycles

by

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No. 149
Abstract

Recently developed testing procedures have led to renewed interest in the empirical evaluation of the hypothesis that business cycle contractions tend to be sharper and shorter than expansions. Evidence presented by Neftci (1984) and Falk (1984) suggests that, in the United States, cycles in unemployment and real GNP behave in ways that are consistent with the asymmetry hypothesis. This paper looks at time series pertaining to aggregate production in Canada and four West European countries. It does not find additional support for the asymmetry hypothesis.
1. Introduction

According to Keynes, one of the regular features of the business cycle is that the length of time it takes for economic activity to go from a peak to a subsequent trough is shorter than the length of time it takes to go from the trough back to the original level of activity. In other words, if one could successfully extract from a time series on a procyclical variable the effects of all those influences other than those germane to the business cycle, the residual series would show a greater tendency to sustain runs of positive first differences than it would to sustain runs of negative first differences. Based upon this notion, Neftci (1984) designed a procedure to test this hypothesis and, on the basis of its application to quarterly, post-war, U.S. unemployment rate data, he found reasonably strong support for the asymmetry hypothesis. Falk (1984) then applied a similar test procedure to quarterly, post-war, U.S. real GDP, real investment, and productivity data. He found the real GDP data to be roughly consistent with what Neftci had found, though the investment and productivity data were not. The present paper extends this line of inquiry by analyzing the extent to which business cycles in five other Western industrial nations are characterized by the kind of asymmetry suggested by Keynes. Specifically, the strategy employed by Neftci and Falk is used to analyze quarterly, post-war, industrial production data for the United Kingdom, France, Canada, Italy, and West Germany.

The resolution of this issue is important because if asymmetry is one of the facts that business cycle theory should explain, it may require a fundamental change in the character of business cycle theories from their present state. The change would have the effect of complicating both the formulation and estimation of such models. In particular, the probability
model that governs the evolution of a time series through downturns may be
different from the probability model governing its evolution through upturns.
Consequently, optimizing agents not only have to forecast a time series' future behavior for a given probability regime, but they must also forecast the regime that will be in effect.

In Section 2, Neftci's basic model and the tests that he and Falk used will be reviewed. Section 3 contains a discussion of the data used in this study, the particular test procedure, and the results. The entire study is summarized in Section 4.

2. Theoretical Model and Test

Let denote the first difference at time of the quarterly, U.S. unemployment rate series. Define a sequence according to if , and if . Neftci assumed that is representable as a stationary, second-order Markov process which, for a given realization of over the interval , has the log-likelihood function

\[
L(S_T, \lambda_{11}, \lambda_{00}, \lambda_{10}, \lambda_{01}, \Pi_0) =
\log \Pi_0 + n_{11} \log \lambda_{11} + T_{11} \log (1 - \lambda_{11}) + n_{00} \log \lambda_{00} + T_{00} \log (1 - \lambda_{00})
\]

\[
+ n_{10} \log \lambda_{10} + T_{10} \log (1 - \lambda_{10}) + n_{01} \log \lambda_{01} + T_{01} \log (1 - \lambda_{01}).
\]

In (1), is the realization of . The parameters , , , are transition probabilities defined according to

\[
\lambda_{11} = p [I_t = 1 | I_{t-1} = 1, I_{t-2} = 1]
\]

\[
\lambda_{00} = p [I_t = -1 | I_{t-1} = -1, I_{t-2} = -1]
\]

\[
\lambda_{10} = p [I_t = 1 | I_{t-1} = -1, I_{t-2} = -1]
\]

\[
\lambda_{01} = p [I_t = -1 | I_{t-1} = 1, I_{t-2} = 1].
\]
\[ \pi_0 \] is the unconditional probability of the initial state \((I_2, I_1)\). The parameters \(n_{11}, \ldots, T_{01}\) denote the number of occurrences of the various states implied by the associated transition probabilities.

Neftci estimated the values of \(\lambda_{00}, \lambda_{11}, \lambda_{10}\) and \(\lambda_{01}\) corresponding to various versions of the unemployment rate and constructed 80% joint confidence regions for \((\lambda_{00}, \lambda_{11})\). These confidence regions were consistently below the 45-degree line (with \(\lambda_{00}\) measured on the horizontal axis) which Nefti took as being consistent with the asymmetry hypothesis.

Falk assumed that Neftci's model would also be appropriate for detrended, quarterly U.S. real GNP, real gross domestic private investment, and productivity. In these three cases, the asymmetry hypothesis would suggest that \(\lambda_{11} > \lambda_{00}\) since all three are procyclical series. What he found was that for real GNP, the point estimate of \(\lambda_{11}\) was greater than the point estimate of \(\lambda_{00}\) and although the 80% confidence region did cross the 45-degree line, that line was fairly close to the region's boundary. However, for both investment and productivity the point estimates of \(\lambda_{11}\) were less than the corresponding estimates of \(\lambda_{00}\). Further, the bulk of both confidence regions fell below the 45-degree line.

The discrepancies between their results may be due to problems that are associated with the strong trends in the variables Falk considered and the way in which they were dealt with. Another point of view is that the kind of asymmetry discussed earlier is characteristic of very broad measures of economic production, such as the unemployment rate and GNP, but it is not characteristic of some more specific measures, including investment and productivity. If this latter view is correct and if business cycles in other
developed industrial economies are roughly similar to those in the U.S. then the tests applied by Neftci and Falk should suggest that cycles in these other economies are asymmetric when broad measures of economic production are considered.

3. Empirical Results

Quarterly data on industrial production from 1951:1 - 1983:4 were collected from the May 1984 edition of Business Conditions Digest for Canada, France, Italy, the United Kingdom, and West Germany. These series all display an obvious positive trend. As Neftci and Falk have argued, the presence of a positive trend in a procyclical time series will incorrectly bias the results toward the asymmetry hypothesis ($\lambda_{11} > \lambda_{00}$) to the extent that the trend is not an intrinsic component of the business cycle. It was assumed here that the industrial production trends in the five countries being considered can be isolated from the business cycle in industrial production this led to the decision to remove the trends by regression methods and focusing on the behavior of the residual series.

Let $X_t^i$ denote the (filtered) value of industrial production for country $i$ at time $t$. The series $\Delta_t^i$ was then constructed according to $\Delta_t^i = X_t^i - X_{t-1}^i$ and the index sequence for country $i$, $I_t^i$ was constructed according to $I_t^i = 1$ if $\Delta_t^i > 0$ and $I_t^i = -1$ if $\Delta_t^i < 0$. The sequence $I_t^i$ was assumed to be representable as a stationary, second-order Markov process so that the log-likelihood function conforms to (1). The realization of $I_t^i$ for $t = 1, ..., T$ defines $S_t$ from which the parameters $\lambda_{00}^i, ..., \lambda_{10}^i$ can be calculated. They are displayed in Table 1 along with the initial states.
Given the values of these parameters and the initial states, the log-likelihood function for each country was numerically maximized across $\lambda_{00}$, $\lambda_{10}$, $\lambda_{01}$, and $\lambda_{11}$ to obtain their point estimates. Given these point estimates, the variance-covariance matrix of the estimates, $V$, can be estimated from the second-derivative matrix of the log-likelihood function, $H$, according to $V = -H^{-1}$. These results are partially summarized in Table 2. Following Neftci and Falk, confidence regions for $(\lambda_{00}, \lambda_{11})$ were calculated for each of the five cases and they are displayed in Figures 1 - 5.

The results do not lend overwhelming support to the view that contractions in economic production tend to be less persistent than expansions. Although in all five cases there are points in the 80-percent region that lie above the diagonal, in only two of those cases (Italy and Canada) were the point estimates of $\lambda_{11}$ greater than the point estimates of $\lambda_{00}$. In both those cases $\lambda_{11}$ and $\lambda_{00}$ were sufficiently close together so that an n-percent confidence region would lie completely above the diagonal for only very small values of n. The other three cases, especially France, seem to be more likely candidates for asymmetry. However, the nature of this asymmetry runs counter to the asymmetry Keynes had suggested and that found by Neftci (in regard to U.S. unemployment data) and Falk (for U.S. GNP data).

4. Summary and Conclusions

The objective of this study was to analyze the cyclical behavior of industrial production in five Western economies to determine whether a compelling picture emerged to support the notion that economic contractions tend to be shorter than economic expansions. Should such a picture have emerged, a formidable challenge to business cycles theorists would have been
presented. One's subjective prior of this kind of result emerging probably would have increased based upon the results Neftci obtained for U.S. unemployment rate data and Falk's results for U.S. real GNP. However, this study uncovered no such compelling evidence. When coupled with the results Falk obtained for investment and productivity series there now appears to be a substantial amount of evidence to justify building theoretical models that do not necessarily generate asymmetric business cycles. To the extent that the results are strongly counter to one's prior, the most likely source of error in these results would seem to be the rough manner in which the trend issue was treated.
Table 1

Summary of the Index Sequence $I_t$

<table>
<thead>
<tr>
<th></th>
<th>United Kingdom</th>
<th>Canada</th>
<th>West Germany</th>
<th>France</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_{00}$</td>
<td>26</td>
<td>24</td>
<td>25</td>
<td>28</td>
<td>22</td>
</tr>
<tr>
<td>$T_{00}$</td>
<td>14</td>
<td>16</td>
<td>12</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>$n_{11}$</td>
<td>17</td>
<td>24</td>
<td>27</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>$T_{11}$</td>
<td>13</td>
<td>15</td>
<td>16</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>$n_{10}$</td>
<td>14</td>
<td>16</td>
<td>16</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>$T_{10}$</td>
<td>16</td>
<td>9</td>
<td>8</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>$n_{01}$</td>
<td>13</td>
<td>16</td>
<td>12</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>$T_{01}$</td>
<td>16</td>
<td>9</td>
<td>13</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>129</td>
<td>129</td>
<td>129</td>
<td>129</td>
<td>129</td>
</tr>
</tbody>
</table>

Initial State
-1,-1          +1,-1          +1,-1          +1,+1          +1,-1
Table 2

Estimation Results

<table>
<thead>
<tr>
<th></th>
<th>United Kingdom</th>
<th>Canada</th>
<th>West Germany</th>
<th>France</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_{00}$</td>
<td>.6614</td>
<td>.5955</td>
<td>.6707</td>
<td>.7125</td>
<td>.560</td>
</tr>
<tr>
<td></td>
<td>(.075)*</td>
<td>(.077)</td>
<td>(.077)</td>
<td>(.072)</td>
<td>(.079)</td>
</tr>
<tr>
<td>$\lambda_{11}$</td>
<td>.5622</td>
<td>.6105</td>
<td>.6230</td>
<td>.5760</td>
<td>.579</td>
</tr>
<tr>
<td></td>
<td>(.090)</td>
<td>(.077)</td>
<td>(.073)</td>
<td>(.088)</td>
<td>(.082)</td>
</tr>
<tr>
<td>$\partial L / \partial \lambda_{00}$</td>
<td>-9.0E-06</td>
<td>-.003</td>
<td>-.007</td>
<td>-1.8E-06</td>
<td>-.002</td>
</tr>
<tr>
<td>$\partial L / \partial \lambda_{11}$</td>
<td>2.0E-08</td>
<td>-.004</td>
<td>-.005</td>
<td>-9.0E-07</td>
<td>-.002</td>
</tr>
<tr>
<td>$\partial^2 L / \partial \lambda_{00}^2$</td>
<td>-177.39</td>
<td>-168.61</td>
<td>-170.64</td>
<td>-194.37</td>
<td>-160.57</td>
</tr>
<tr>
<td>$\partial^2 L / \partial \lambda_{11}^2$</td>
<td>-123.81</td>
<td>-166.75</td>
<td>-186.10</td>
<td>-128.99</td>
<td>-149.94</td>
</tr>
<tr>
<td>$\partial^2 L / \partial \lambda_{00} \partial \lambda_{11}$</td>
<td>.497</td>
<td>.601</td>
<td>.754</td>
<td>.603</td>
<td>.448</td>
</tr>
</tbody>
</table>

*: Standard errors in parentheses
Figure 1

Industrial Production: United Kingdom

$H_0: \lambda_{11} > \lambda_{00}$

80% Confidence Region

\[ \hat{\lambda}_{11} = 0.56 \]

\[ 0.66 \approx \hat{\lambda}_{00} \]
Figure 2

Industrial Production: Canada

$H_0: \lambda_{11} > \lambda_{00}$

80% Confidence Region
Figure 3

Industrial Production: West Germany

$H_0: \lambda_{11} > \lambda_{00}$

80% Confidence Region
Figure 4

Industrial Production: France

\[ H_0: \lambda_{11} > \lambda_{00} \]

80% Confidence Region
Figure 5

Industrial Production: Italy

\[ H_0: \lambda_{11} > \lambda_{00} \]

80\% Confidence Region
Notes

1/ See Keynes (1936, p. 314).

2/ The null hypothesis of symmetry could be rejected at the 80 percent confidence level.

3/ Although the productivity data lent some support to the asymmetry hypothesis, the asymmetry suggested was that contractions tend to last longer than expansions.

4/ See Neftci (pp. 308-309 and pp. 324-325).

5/ The value of $\Pi_0$ depends upon the $\lambda$'s. For estimation purposes, Neftci and Falk used the asymptotically correct values of $\Pi_0$ as approximations. These values can be calculated according to the formulae given by Neftci (p. 327) and Falk (p. 15, footnote 5).

6/ Since the unemployment rate is countercyclical, the prior assumption for that series would be $\lambda_{00} > \lambda_{11}$.

7/ So much of the region for productivity fell below the diagonal that the data seem to support an asymmetry hypothesis of the form $\lambda_{00} > \lambda_{11}$.

8/ This issue will be considered further in the next section.

9/ The choice of quarterly data conforms to the sample interval selected by Neftci and Falk.

10/ If the time series is procyclical then the asymmetry hypothesis is that runs of increasing values are more likely to persist than are runs of decreasing values. If the series is also characterized by a positive trend that will also contribute to making increasing runs more sustainable than decreasing runs. On the other hand, a countercyclical time series would, under the null hypothesis, have a greater tendency toward decreasing runs.
In this case the bias introduced by a positive trend would work against the null hypothesis.

\(^{11/}\) Visual inspection of the five time series strongly suggest a significant drop in the trend after 1972:4. Thus, each regression's independent variables were a constant and two trend variables. One whose value was zero for all observations after 1972:4 and another whose value was zero for all observations on or before that date.

\(^{12/}\) The log-likelihood function was numerically maximized via the GRADX algorithm of the GQOPT library (available through the Economics Department at Princeton University).

\(^{13/}\) The confidence regions were derived as the solutions to quadratic expressions of the form:

\[
(\lambda - \hat{\lambda})'(-H)(\lambda - \hat{\lambda}) = \chi^2 \left( .80 \right)
\]

where \(\lambda = [\lambda_0 \quad \lambda_1]'\) and \(H\) is the matrix of second partial derivatives of the log-likelihood function evaluated at \(\lambda = \hat{\lambda}\).
References


