ON THE SOURCES OF THE GREAT MODERATION
JORDI GALÍ & LUCA GAMBETTI

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Main Points

1. Volatility of output, hours, and labor productivity declined dramatically since mid 80s
   • volatility of hours and labor productivity has risen *relative* to volatility of output

2. Significant change in correlation structure.
   • Correlation of hours and productivity from 0 to (-)
   • Correlation of output and labor productivity (+) to 0

3. Sharp fall in contribution of non-technology shocks to variance of output.

4. Structural Answers:
   • Interest-rate rule favoring inflation stabilization
   • End of short-run increasing returns to labor (SRIRL)
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4. Structural Answers
   • Interest-rate rule favoring inflation stabilization
   • End of short-run increasing returns to labor (SRIRL)
Table 3. Changes in Cross-Correlations

<table>
<thead>
<tr>
<th>First-Difference</th>
<th>pre-84</th>
<th>post-84</th>
<th>change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output, Hours</td>
<td>0.78</td>
<td>0.57</td>
<td>−0.20**</td>
</tr>
<tr>
<td>Hours, Productivity</td>
<td>0.18</td>
<td>-0.41</td>
<td>−0.59**</td>
</tr>
<tr>
<td>Output, Productivity</td>
<td>0.75</td>
<td>0.50</td>
<td>−0.24**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BP-Filter</th>
<th>pre-84</th>
<th>post-84</th>
<th>change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output, Hours</td>
<td>0.87</td>
<td>0.84</td>
<td>−0.03</td>
</tr>
<tr>
<td>Hours, Productivity</td>
<td>0.16</td>
<td>-0.42</td>
<td>−0.59**</td>
</tr>
<tr>
<td>Output, Productivity</td>
<td>0.62</td>
<td>0.12</td>
<td>−0.49**</td>
</tr>
</tbody>
</table>

Note: Test of equality of correlations across the two subsamples based on the asymptotic standard errors of estimated correlations computed using an 8-lag window. (see, e.g., Box and Jenkins (1976), p. 376). One asterisk denotes significance at the 10 percent level. Two asterisks indicate significance at the 5 percent level.
Evidence Against “Strong Form” of Good Luck Hypothesis

1. Strong form = proportional decline in variance of all shocks

2. Weak form = disproportional decline in variance of shocks

If strong form holds, no change in correlation structure.
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If strong form holds, no change in correlation structure.
Can always write solution of LRE model as MA representation:

\[ X_t = D(L)\epsilon_t, \quad Y_t = F(L)\epsilon_t \]

where \( D(L) = d_0 + d_1 L + d_2 L^2 + \cdots \)

\[
\text{Cov}(X_t, Y_t) = \frac{\sigma^2}{2\pi i} \oint F(z)D(z^{-1}) \frac{dz}{z}
\]

\[
\text{Var}(X_t) = \frac{\sigma^2}{2\pi i} \oint D(z)D(z^{-1}) \frac{dz}{z}
\]

\[
\text{Var}(Y_t) = \frac{\sigma^2}{2\pi i} \oint F(z)F(z^{-1}) \frac{dz}{z}
\]

Correlation structure will not change with change in \( \sigma^2 \)

Correlation structure will change with change in structural parameters \((d_i, f_i)\).
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\text{Cov}(X_t, Y_t) = \frac{\sigma_\epsilon^2}{2\pi i} \oint F(z)D(z^{-1}) \frac{dz}{z}
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\text{Var}(X_t) = \frac{\sigma_\epsilon^2}{2\pi i} \oint D(z)D(z^{-1}) \frac{dz}{z}
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Must use theory to explain the drastic change in correlation structure.
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THEORETICAL EXPLANATIONS

1. Monetary Policy [Clarida et al. (2000)]

2. Inventory Management [Kahn et al. (2002)]

3. Financial Innovation [Dynan et al. (2006)]

4. Gali and Gambetti focus on monetary policy and returns to labor.
**Stylized Model**

“Suggestive” and “Simple” New Keynesian Model

\[ y_t = E_t(y_{t+1}) - (i_t - E_t(\pi_{t+1})) + d_t \]  \hspace{1cm} (4)

\[ \pi_t = \beta E_t(\pi_{t+1}) + \kappa(y_t - a_t) \]  \hspace{1cm} (5)

\[ i_t = \phi_\pi \pi_t + \phi_y \Delta y_t \]  \hspace{1cm} (6)

\[ y_t = a_t + \gamma n_t \]  \hspace{1cm} (7)

\( y_t \) is log output

\( n_t \) is log hours

\( i_t \) is short-term nominal rate

\( \pi_t \) is inflation

\( \pi_{t+1} \) is inflation

\( d_t \) is exogenous demand shock

\( a_t \) is exogenous technology shock


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(4) Comes from HH’s Euler equation
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(5) New Keynesian Phillips curve
STYLISTED MODEL

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(6) Taylor-type interest rate rule


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(7) Reduced form aggregate production (\( \gamma > 1 \) implies SRIRL)
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(4) Comes from HH’s Euler equation
(5) New Keynesian Phillips curve
(6) Taylor-type interest rate rule
(7) Reduced form aggregate production (\( \gamma > 1 \) implies SRIRL)
\( \Delta a_t \) and \( d_t \) assumed to be AR(1)
**Stylized Model**

“Suggestive” and “Simple” New Keynesian Model

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y_t = E_t(y_{t+1}) - (i_t - E_t(\pi_{t+1})) + d_t
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\[
y_t = a_t + \gamma n_t
\]

To what extent can the (relatively small) changes in the three structural parameters ($\gamma$, $\phi_\pi$, $\phi_y$) account for the variation in estimated second moments between the pre-1984 and post-1984 periods?


**Simple Sensitivity Analysis**

1. **Can pure good luck account for almost all of the reduction in volatility of output?**

2. 

3. 
GOOD-POLICY CALIBRATION

Permanent Parameters
\[ \beta = 0.99, \ \kappa = 0.34, \ \rho_a = 0.1, \ \rho_d = 0.5 \]

Varying Parameters
Pre-84 \[ \gamma = 1.1, \ \phi_\pi = 1.01, \ \phi_y = 0.25 \]
Post-84 \[ \gamma = 0.9, \ \phi_\pi = 2.0, \ \phi_y = 0.1 \]

Calibration
Find \( \sigma_a, \sigma_d \) to match
1. Pre-84 Unconditional Volatility of Output Growth (1.57)
2. Pre-84 Conditional Volatilities of Output Growth (1.14 / 0.52)
\[ \gamma = 1.1, \ \phi_y = \text{linspace}(0.25, 0.1), \ \phi_\pi = \text{linspace}(1.01, 2) \]
GOOD-LUCK CALIBRATION

Permanent Parameters
\[ \beta = 0.99, \kappa = 0.34, \rho_a = 0.1, \rho_d = 0.5 \]

Calibration
Find \( \sigma_a, \sigma_d \) to match
1a. Pre-84 Unconditional Volatility of Output Growth (1.57)
2a. Pre-84 Conditional Volatilities of Output Growth (1.14 / 0.52)
1b. Post-84 Unconditional Volatility of Output Growth (1.10)
2b. Post-84 Conditional Volatilities of Output Growth (0.62/ 0.54)

Vary \( \sigma_a \) and \( \sigma_d \) but keep pre-84 policy parameters.
Fig 2: Standard Deviation of Output

\[ \sigma_a = \text{linspace}(1.81, 0.73), \quad \sigma_d = \text{linspace}(0.77, 0.48) \]

Assume Pre-84 Policy Rule
Good-Luck Calibration

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\[ \sigma_a = \text{linspace}(1.81, 0.73), \quad \sigma_d = \text{linspace}(0.77, 0.48) \]

Assume Pre-84 Policy Rule
Simple Sensitivity Analysis

1. Can pure good luck account for almost all of the reduction in volatility of output?

   Yes, but what about other moments?

2. 

3. 
Simple Sensitivity Analysis

1. Can pure good luck account for almost all of the reduction in volatility of output?

2. How to interpret change in SRIRL?

3.
**CALIBRATION**

**Permanent Parameters**
\[ \beta = 0.99, \ \kappa = 0.34, \ \rho_a = 0.1, \ \rho_d = 0.5 \]

**Calibration**
Pre-84 Policy Rules \( \phi_\pi = 1.01, \ \phi_y = 0.25 \)

Find \( \sigma_a, \sigma_d \) to match
1. Pre-84 Unconditional Volatility of Output Growth (1.57)
2. Pre-84 Conditional Volatilities of Output Growth (1.14 / 0.52)
3. Must match Table 6: Volatility of Pre-84 Hours (1.3)
Fig 4: Standard Deviation of Hours

\( \gamma = \text{linspace}(1.1, 0.9) \), Assume Pre-84 Policy Rule
Fig 5: Correlation of Hours and Productivity

$\gamma = \text{linspace}(1.1, 0.9)$, Assume Pre-84 Policy Rule
SIMPLE SENSITIVITY ANALYSIS

1. Can pure good luck account for almost all of the reduction in volatility of output?

2. **How to interpret change in SRIRL?**
   Without SRIRL, (-) correlation between hours and productivity

3. 
1. Can pure good luck account for almost all of the reduction in volatility of output?

2. How to interpret change in SRIRL?

3. If time variation in parameters is important, how should model be constructed?
Regime Switching

- Won’t rational agents take regime change seriously and form probabilistic distributions over regimes?

- Davig-Leeper (2007) show policy can deviate from Taylor rule in short-run if deviations are small or not prolonged.

- Assume switching in structural parameters is driven by two-state Markov chain $\gamma(s_t), \phi_\pi(s_t), \phi_y(s_t)$ with $p_{11} = 0.75, p_{22} = 0.95, p_{ij} = 1 - p_{ii}$ where $i \neq j$.
  
  State 1: $\gamma_1 = 1.1, \phi_1,\pi = 0.95, \phi_{1,y} = 0.25$

  State 2: $\gamma_2 = 0.9, \phi_{2,\pi} = 2, \phi_{2,y} = 0.1$

- Calibrate to hit post-84 volatilities in regime 2:
  
  Standard Deviation of Output in Regime 1 is 1.25 (Data 1.57)
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Other Issues

• Why not include policy variables or inflation in VAR? (long-run restrictions, and increase in number of parameters to estimate) Why not report percentiles of posterior?

• Identification: Strong dynamic restrictions must be placed on the VAR to impose long-run identifying restrictions [Faust-Leeper (1997), Robertds (1996)]. How does this change with time-dependent parameters?

\[
X_t = F(L)u_t \\
X_t = F(L)A_0 A_0^{-1} u_t \\
\epsilon_t = A_0^{-1} u_t \\
[F(1)A_0]_{i,j} = 0 \\
[F_t(1)A_{t0}]_{i,j} = 0?
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Conclusion

- Compelling empirical conclusions.

- Good Luck or Good Policy? Yes. As with most any economic question, answer is probably somewhere in the middle.

- This paper suggests that more work needs to be done in understanding the structural changes that have led to the great moderation.
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