Discussion of

“CES Technology and Business Cycle Fluctuations”

Peter McAdam
ECB and University of Surrey

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Outline

• Motivation: why the authors are doing what they're doing.
• Method: how exactly they did it.
• Outcome: what they found.
• Main Issues.
• Lesser Issues.
• Conclusions.
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• **Conclusions.**
Cristiano, Paul & Bo try to do the following ...

- Embed CES aggregate technology in SW-like (2007).
- Take Normalization seriously in an estimated DSGE model.
- Perform an Odds-Ratio comparison with CD based and DSGE-Var based alternatives.
Why are they trying to do this?

1. Prior that CD is overly restrictive formulation of aggregate supply.
2. Improve statistical model fit viz-a-viz the data
3. Capture key volatilities better
4. Advance the CES and *normalization* agenda.
Method

- Re-do the estimation of this “supply-augmented” SW model
- Trend for measurement variables estimated.
- DSGE & DSGE-Var framework.
- Odds-Ratio comparison.
1. Implementation of the normalized CES production function.
2. The Empirical Results: Estimation and Identification
3. Odds Ratio Result
4. Variance Decomposition
1. Implementation of the normalized CES production function.
Issues

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- The point of normalization makes more sense as a data sample context, not a steady state growth point.

- Two assumptions being imposed by SS growth point: (1) that the BGP growth rate is constant (ii) that technical progress is Harrod Neutral.

- Neither of these properties hold in the data.

- Implementation of factor-augmenting CES Production should force you to think about balanced growth. If $ZK > 0$ there is no balanced growth. Plot of Labor Share proves it.
2. The Empirical Results: Estimation and Identification

- The data are uninformative about the key parameters, $\rho_{zk}$ and $e_{zk}$.

- PC slope still flat.

- This study forces us into new territory and puts identification issues to the forefront (e.g., capital-augmentation vs. Investment-specific) yet very limited diagnostics presented.
Capital-Augmenting Technology Process Parameters

\[ e_{ZK} \]

\[ \rho_{ZK} \]
3. Variance Decomposition

- Are these decompositions for the levels or the growth rates of the observables? It matters. Technology drives the levels of, say output, but will have less impact on the difference.

- That said, some of these decompositions look big.
<table>
<thead>
<tr>
<th>Forecast horizon</th>
<th>Observable variables</th>
<th>Productivity (K)</th>
<th>Productivity (L)</th>
<th>Government spending (price)</th>
<th>Mark-up</th>
<th>Investment (wage)</th>
<th>Mark-up</th>
<th>Monetary policy</th>
<th>Preference</th>
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<tbody>
<tr>
<td>t=1</td>
<td>Output</td>
<td>6.1 (7.1)</td>
<td>32.4 (31.9)</td>
<td>21.4 (19.4)</td>
<td>14.2 (12.6)</td>
<td>20.3 (23.3)</td>
<td>3.9 (2.9)</td>
<td>2.4 (2.8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consumption</td>
<td>6.8 (5.0)</td>
<td>4.2 (10.0)</td>
<td>12.2 (7.2)</td>
<td>1.8 (0.9)</td>
<td>32.5 (31.6)</td>
<td>9.1 (3.9)</td>
<td>33.4 (41.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Investment</td>
<td>5.4 (9.7)</td>
<td>0.2 (2.0)</td>
<td>24.7 (26.4)</td>
<td>51.3 (38.6)</td>
<td>14.8 (19.3)</td>
<td>1.2 (2.1)</td>
<td>2.3 (2.0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inflation</td>
<td>15.6 (12.3)</td>
<td>2.4 (12.9)</td>
<td>24.7 (13.5)</td>
<td>15.0 (30.7)</td>
<td>16.6 (3.5)</td>
<td>13.5 (17.4)</td>
<td>12.3 (9.7)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Real wage</td>
<td>5.7 (3.4)</td>
<td>0.01 (2.3)</td>
<td>49.5 (33.0)</td>
<td>0.02 (0.1)</td>
<td>29.6 (32.8)</td>
<td>4.0 (0.9)</td>
<td>11.2 (7.6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interest rate</td>
<td>6.4 (7.7)</td>
<td>1.0 (8.0)</td>
<td>9.6 (6.5)</td>
<td>6.1 (18.6)</td>
<td>6.4 (1.3)</td>
<td>65.3 (51.2)</td>
<td>5.1 (6.6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hours worked</td>
<td>12.3 (12.2)</td>
<td>30.5 (30.2)</td>
<td>19.0 (17.7)</td>
<td>15.2 (11.9)</td>
<td>19.5 (22.8)</td>
<td>3.5 (2.7)</td>
<td>2.1 (2.5)</td>
<td></td>
</tr>
</tbody>
</table>

| t=4              | Output               | 6.8 (7.7)        | 23.8 (27.9)      | 25.7 (20.5)                | 12.5 (10.4) | 25.1 (26.9) | 3.0 (2.6) | 3.1 (4.0)      |            |
|                  | Consumption          | 7.6 (4.9)        | 4.5 (10.0)       | 13.0 (6.9)                 | 2.1 (1.3)  | 35.3 (32.1) | 8.4 (3.8) | 29.2 (41.0)    |            |
|                  | Investment           | 6.6 (9.9)        | 0.3 (2.5)        | 30.2 (28.6)                | 39.5 (30.7) | 20.0 (24.6) | 0.8 (1.8) | 2.7 (1.9)      |            |
|                  | Inflation            | 11.4 (8.7)       | 2.3 (10.2)       | 15.5 (9.9)                 | 25.1 (38.6) | 17.5 (3.1) | 16.8 (21.8) | 11.4 (7.5)    |            |
|                  | Real wage            | 6.7 (3.4)        | 0.2 (2.4)        | 53.1 (33.7)                | 0.4 (0.4)  | 25.4 (50.5) | 3.7 (0.9) | 10.5 (8.5)     |            |
|                  | Interest rate        | 10.7 (7.0)       | 2.5 (12.0)       | 10.1 (3.4)                 | 26.5 (53.5) | 18.3 (13.7) | 21.9 (15.9) | 11.9 (7.0)    |            |
|                  | Hours worked         | 2.0 (2.4)        | 10.7 (9.5)       | 35.2 (31.8)                | 13.2 (7.9) | 30.9 (46.7) | 1.5 (1.1) | 0.5 (0.6)      |            |

| t=10             | Output               | 6.8 (8.3)        | 23.2 (27.4)      | 25.2 (20.22)               | 13.7 (11.0) | 24.8 (26.5) | 3.1 (2.7) | 3.3 (4.0)      |            |
|                  | Consumption          | 7.6 (4.8)        | 4.3 (9.8)        | 12.8 (6.9)                 | 3.3 (3.7)  | 34.3 (31.1) | 8.4 (3.7) | 29.4 (39.9)    |            |
|                  | Investment           | 6.3 (10.5)       | 0.3 (2.5)        | 28.4 (27.0)                | 42.2 (32.8) | 19.1 (23.1) | 0.9 (1.8) | 2.9 (2.3)      |            |
|                  | Inflation            | 10.9 (8.7)       | 2.3 (9.9)        | 16.7 (10.3)                | 26.1 (38.5) | 16.5 (4.0) | 16.2 (20.8) | 11.3 (7.8)    |            |
|                  | Real wage            | 6.7 (3.3)        | 0.2 (2.4)        | 51.6 (33.0)                | 0.4 (0.9)  | 26.1 (51.1) | 3.9 (0.9) | 11.1 (8.4)     |            |
|                  | Interest rate        | 8.6 (5.3)        | 3.2 (12.7)       | 7.9 (8.7)                  | 41.0 (54.6) | 15.5 (17.7) | 14.0 (11.9) | 9.8 (5.2)     |            |
|                  | Hours worked         | 1.3 (1.1)        | 6.0 (4.6)        | 41.1 (32.3)                | 7.1 (3.4)  | 43.5 (57.8) | 0.6 (0.5) | 0.5 (0.3)      |            |

| t=100            | Output               | 7.1 (8.4)        | 22.2 (27.1)      | 25.4 (20.4)                | 13.5 (10.9) | 25.7 (26.7) | 3.0 (2.6) | 3.2 (3.9)      |            |
|                  | Consumption          | 7.6 (4.8)        | 4.3 (9.8)        | 12.9 (7.7)                 | 3.9 (3.8)  | 34.3 (31.5) | 8.2 (3.6) | 28.8 (38.8)    |            |
|                  | Investment           | 6.8 (10.6)       | 0.3 (2.6)        | 28.8 (27.3)                | 40.4 (31.9) | 20.2 (23.6) | 0.8 (1.7) | 2.9 (2.3)      |            |
|                  | Inflation            | 10.3 (5.6)       | 2.6 (6.4)        | 18.1 (16.5)                | 25.2 (23.8) | 18.7 (30.1) | 14.8 (12.4) | 10.3 (4.6)    |            |
|                  | Real wage            | 6.9 (3.3)        | 0.2 (2.3)        | 51.8 (32.5)                | 0.5 (1.1)  | 26.0 (51.8) | 3.9 (0.8) | 10.8 (8.1)     |            |
|                  | Interest rate        | 7.9 (3.7)        | 4.7 (8.0)        | 13.7 (18.2)                | 34.8 (25.2) | 20.6 (37.5) | 10.8 (4.9) | 7.6 (2.2)      |            |
|                  | Hours worked         | 1.0 (0.4)        | 6.3 (2.1)        | 45.2 (27.5)                | 5.2 (1.4)  | 41.5 (68.3) | 0.4 (0.2) | 0.4 (0.1)      |            |

Table 4: Variance Decomposition - Comparison of CD and CES Specifications (in Percent)
4. Odds Ratio

CES beats CD 100-to-1!

On the face of it, this looks really powerful!

But what concept of likelihood are you using: Laplace Approximation, MHM?

Has the Markov Chain fully converged?

Log difference is only 10. Are the authors comfortable with making such claims of dominance?
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• IRFs: actually relatively little difference between CES and CD alternatives.

• IRFs: hump shaped ...?

• Bayesian-Maximum Likelihood?

• “Capital-Biased technical” progress.
Figure 6: Bayesian IRFs - Labour-augmenting shock
Conclusions

• Really stimulating paper! Asks all the right questions! Wish it had occurred to me to write it before them!
• Should convince people that the convenience and centrality of Cobb-Douglas production functions in macro is obscuring important issues (especially so over b/cycle frequencies).
• Incorporating factor-augmenting CES aggregate production-technology system holds out enormous promise - better models, better understanding of the data.
• The process of implementation and identification is far from trivial.
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