Human Capital Adjusted Production Function

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Outline

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Motivation

- Estimates of potential output (sustainable level of output) are highly relevant to fiscal monitoring and policy formation.

- Legally bound to the harmonised methodology in estimating potential output.

- Limitations of status-quo approach in the Irish case. Estimates are pro-cyclical.

- We attempt to improve the performance of the harmonised methodology by embedding a measure of human capital.
Whilst the importance of human capital in fostering long-term economic growth is widely recognised, it is currently not included in alternative methodologies applied by leading international or domestic institutions.

Similarly, independent research has not explored the impact of human capital on potential output for Ireland.

This work contributes to efforts aimed at developing alternative estimates of potential output for Ireland.

This work also contributes to efforts aimed at estimating the human capital stock for Ireland (Bergin, Kearney (2004); Barro, Lee (2010); Cohen, Soto (2014)).

We construct a new refined measure of the effective human capital utilised in the production process.
Literature Review

- Large volume of research establishes a positive relationship between human capital and income:
  - Cross-country growth accounting (Mankiw, Romer, & Weil (1992); Barro & Lee (2007); De la Fuente & Domenech (2002))
  - Labour market research (Mincer (1974), Montenegro & Patrinos (2014))

- Human capital measurement
  - Monetary approaches (Kendrick (1976))
  - Education indicators (OECD (2013); Barro & Lee (2007))
Methodology

- We introduce human capital by augmenting labour:
  \[ Y = (TFP)(hL)^\alpha K^{(1-\alpha)} \]

Potential factor inputs

- **Human capital:** \( h = e^{r(S)} \); \( S \) = weighted measure of schooling years, \( r \) = returns to education (ESRI 2001)
- **Potential labour input:** \( L = Pop \times (PR) \times (1 - NAWRU) \times HperE \)
- **Total Factor Productivity:** As a result of introducing human capital, an alternative Kalman filter to de-trend TFP must be constructed

\[
\begin{align*}
TFP_t &= p_t + c_t \\
CU_t &= \mu_{cu} + \beta c_t + a_{cu,t} \\
p_t &= p_{t-1} + \eta_{t-1} + \delta D_t \\
\eta_t &= \rho \eta_{t-1} + a_{\eta,t} \\
c_t &= \phi_{c1} c_{t-1} + \phi_{c2} c_{t-2} + a_{c,t}
\end{align*}
\]

- Sample period 1980 – 2018
Methodology

  1. Less than primary, Primary, Lower secondary
  2. Upper secondary, Post-secondary non-tertiary
  3. Tertiary

- Calculate total hours worked by education category:
  \[ \text{Total hours}_i = \text{Pop}_i \times \text{PR}_i \times (1 - UR_i) \times \text{hpere}_i \]

- Average years of schooling calculated as the weighted average of durations of the three education categories:
  \[ S = \sum_{i=1}^{3} \frac{\text{Duration}_i \times \text{Total hours}_i}{\text{Total hours}} \]

- Refined measure indicates a higher human capital stock.
Improvements in the educational composition of the population...

**Working Age Population (15-74Y)**

- **Tertiary**
- **Upper secondary, Post-secondary**
- **Less than primary, Primary, Lower Secondary**
- **Total**

**Population by education and age, 2016**

- Less than primary, Primary, Lower secondary
- Upper secondary, Post-secondary
- Tertiary
Significant variation in labour market indicators by education...

**Participation Rate**

- Total
- Less than primary, Primary, Lower Secondary
- Upper secondary, Post-secondary
- Tertiary

**Unemployment Rate**

- Total
- Less than primary, Primary, Lower Secondary
- Upper secondary, Post-secondary
- Tertiary
The total hours worked are heavily weighted toward tertiary level of education...
The contribution of human capital to potential output growth is 0.4 percentage points on average over 1992-2016.

Relatively strong contribution over 2009 – 2012, reflecting labour market shift toward workers with higher levels of education.

Relatively lower contribution in the years since 2013, reflecting the re-entry of lower educated workers into the workforce.
Results

- The human capital adjusted model appears to better detect the cyclical position of the economy.

- However, the output gap estimates remain broadly within the same neighbourhood.

- Human capital is a slow-moving variable and its impact would have, to some degree, already been captured within the TFP residual.

- Further adjustments are required to significantly improve the performance of the harmonised methodology.
We estimate that the effective stock of human capital has increased by around 20 per cent since 1992. We estimate relatively strong increases during the recent recession, and relatively low increases in the following years as labour market conditions improve.

Inclusion of a human capital element appears to slightly improve the sensibility of estimates of potential output and the cyclical position of the economy.

However, estimates remain broadly within the same range, likely reflecting the stability of human capital.

While inclusion of human capital appears to improve the performance of the methodology, further adjustments required to target other issues in relation to labour and capital which fall beyond the scope of this research.
Thank you for your attention!
Comments/Questions are welcome
Appendix (Output Gap)

Output Gap

% of potential output

-8 -6 -4 -2 0 2 4 6 8 10


IMF  OECD  DoF
Appendix (Data)

Every one in two workers is now tertiary level educated...

![Graph showing employment and contributions to employment growth from 1992 to 2018. The graph indicates a significant increase in tertiary education levels over time.]
Appendix (Robustness)

- Results are quite robust to alternative Irish-specific estimates of returns to education.

- Some (but not substantial) sensitivity to the returns to education function previously used by the OECD:
  - cross-country estimated function of quadratic form which allows for decreasing returns to education
  - potential output growth is slightly higher; the output gap is broadly unchanged in the years prior to 2008 and slightly more negative in the subsequent years.

- Some (but not substantial) sensitivity to mechanically forecasting the average years of schooling:
  - This approach implies a stronger increase in the average years of schooling
  - Potential output growth is slightly higher; the output gap is slightly more negative over the majority of the sample period, highlighting the need for further work to stabilise the Kalman filter.
Appendix (Harmonised Methodology)

\[ Y = (TFP)(L)^\alpha K^{(1-\alpha)} \]

*Potential Labour Input:*
\[ L^* = Pop \times (PR^*) \times (1 - NAWRU) \times HperE^* \]

*Filters:*
- HP filter used to de-trend \( PR \) & \( HperE \)
- Kalman Filter used to de-trend \( TFP \) and to estimate the NAWRU

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Y</td>
<td>Real Gross Domestic Product</td>
</tr>
<tr>
<td>TFP</td>
<td>Total Factor Productivity</td>
</tr>
<tr>
<td>L</td>
<td>Labour Input</td>
</tr>
<tr>
<td>K</td>
<td>Capital</td>
</tr>
<tr>
<td>Pop</td>
<td>Working Age Population (15-74Y)</td>
</tr>
<tr>
<td>PR</td>
<td>Participation Rate</td>
</tr>
<tr>
<td>NAWRU</td>
<td>Non-Accelerating Wage Rate of Unemployment</td>
</tr>
<tr>
<td>HperE</td>
<td>Average hours worked per employee</td>
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