INFORTW:
An Inter-industry Forecasting Model of the Taiwanese Economy

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Introduction

- INFORTW
  - Inter-industry Forecasting Model of Taiwan

- Outline
  - Research motivation and literature reviews
  - INFORTW model development
  - Scenarios and estimated results
  - Conclusions and suggestions
Research Motivation

- To use the survey and data foundation of the Industrial Economic and Knowledge (IEK) Center
- To systematize the industrial analysis
- To develop a national economic (top-down) model and cooperate to the FORECAST/MURE (bottom-up) model

INFORTW
(Top-down economic model)
GDP, production, labor, price...

FORECAST/MURE
(Bottom-up technical model)
Energy consumption, technical improvement...
Literature Reviews (1/2)

Multisectoral Models

- **Johanson-type**
  - Johansen (1960)
  - Dixon et al. (1982)

- **Scarf-type**
  - Adelman (1969)
  - Shoven and Whalley (1984)
  - Dervis et al. (1982)

- **Jorgenson-type**
  - Hudson and Jorgenson (1974)
  - Jorgenson and Wilcoxen (1990)

- **Inforum-type**
  - Monaco (1991)
  - Nyhys (1991)
Literature Reviews  (2/2)

- **MUDAN** (Yu, 1997) - China
- **INFORGE** (Ahlert, 2001; Bach et al., 2002; Lutz et al., 2005, 2007; Meyer et al., 2007a, 2007b; Giljum et al., 2008; Lehr et al., 2008; Wiebe et al., 2012) - Germany
- **ITIMO** (Bardazzi et al., 1991; Bardazzi and Barnabani, 2001) - Italy
- **JIDEA** - Japan
- **IMPEC** (Orlowski and Tomaszewicz, 1991) - Poland
- **MIDE** (Werling, 1992) - Spain
- **LIFT** (McCarthy, 1991; Dowd et al., 1998) - U.S.
- **INFORTW** - Taiwan
## Model INFOR-TW (1/6)

### Price-Income Side

<table>
<thead>
<tr>
<th></th>
<th>p</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>f</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>p1</td>
<td>y11</td>
<td>y12</td>
<td>y13</td>
<td>c1</td>
<td>i1</td>
</tr>
<tr>
<td>#2</td>
<td>p2</td>
<td>y21</td>
<td>y22</td>
<td>y23</td>
<td>c2</td>
<td>i2</td>
</tr>
<tr>
<td>#3</td>
<td>p3</td>
<td>y31</td>
<td>y32</td>
<td>y33</td>
<td>c3</td>
<td>i3</td>
</tr>
</tbody>
</table>

### Real Side

\[
A = \begin{bmatrix}
      a_{11} & a_{12} & a_{13} \\
      a_{21} & a_{22} & a_{23} \\
      a_{31} & a_{32} & a_{33}
\end{bmatrix}
\]

\[
y = \begin{bmatrix}
      y_1 \\
      y_2 \\
      y_3
\end{bmatrix},
\quad f = \begin{bmatrix}
      f_1 \\
      f_2 \\
      f_3
\end{bmatrix},
\quad c = \begin{bmatrix}
      c_1 \\
      c_2 \\
      c_3
\end{bmatrix}
\]

\[
f = c + i + g + x - m
\]

\[
va = w + d + pr + tax
\]

\[
v = \frac{va}{y}
\]

\[
y = Ay + f
\]

\[\Rightarrow\]

\[
y = (I_o - A)^{-1} f
\]

\[
p = A' p + v
\]

\[\Rightarrow\]

\[
p = (I_o - A')^{-1} v
\]
Model INFORTW  (2/6)

- **Estimation of final demands (Real side)**
  - Consumption demand
    \[ c_{i,t} = C(c_{i,t-1}, p_{i,t}, y_{t}, t), \ i = 1, \ldots 13 \]
  - Investment demand
    \[ i_{i,t} = I(i_{i,t-1}, y_{i,t}, r_{t}, t), \ i = 1, \ldots 19 \]
  - Government expenditure
given as an exogenous variable
  - Export
    \[ e_{i,t} = E(e_{i,t-1}, p_{i,t}^e, p_{f,t}^f, y_{f,t}), \ i = 1, \ldots 47 \]
  - Import
    \[ m_{i,t} = M(m_{i,t-1}, p_{i,t}^m, p_{i,t}, y_{t}), \ i = 1, \ldots 47 \]
Model INFORTW  (3/6)

- **Estimation of value added** (Price-income side)
  - Wage, Labor productivity & Labor demand
    \[ w_{i,t} = W(w_{i,t-1}, w_t, prl_{i,t}), \ i = 1, \ldots 47 \]
    \[ prl_{i,t} = PRL(\Delta y_{i,t}, i_{i,t-1}, t), \ i = 1, \ldots 47 \]
    \[ l_{i,t} = \frac{y_{i,t}}{prl_{i,t}}, \ i = 1, \ldots 47 \]
  - Depreciation expense
    \[ d_{i,t} = D(d_{i,t-1}, k_{i,t}, t), \ i = 1, \ldots 47 \]
  - Operating profit
    \[ pr_{i,t} = PR(pr_{i,t-1}, \Delta y_{i,t}, p_{i,t-1}), \ i = 1, \ldots 47 \]
  - Indirect tax
    \[ tax_{i,t} = TAX(va_{i,t}, t), \ i = 1, \ldots 47 \]
Model INFORTW (4/6)

- Connection & Equilibrium
  (Stata v.13)
Model INFORTW (5/6)

- **Data source**
  - Directorate General of Budget, Accounting and Statistics (DGBAS) of Taiwan
    - Annual national account
    - 5-year updated input–output table
  - Ministry of Finance of Taiwan
    - Export & import (price & quantity)
  - World Development Indicators (WDI) of the World Bank
    - World production and price

Data mismatch problem ➔ RAS method
RAS method*

- Solve *biproportional constrained matrix problem*
  - Data mismatch between I–O tables and national accounts
  - I–O tables update every five years

*RAS method*

Given a nonnegative matrix $A$ ($m \times n$) and positive vectors $u$, $v$, then the biproportional constrained matrix problem is to find a nonnegative matrix $B$ ($m \times n$) such that $B = diag(r) \ A \ diag(s)$ holds for vectors $r \in \mathbb{R}^m$ and $s \in \mathbb{R}^n$, and the row (column) sums of $B$ equal to $u_i$ ($v_j$), $i = 1, \ldots, m$ ($j = 1, \ldots, n$).

(Bacharach, 1970)
### Scenarios

- **Energy efficiency improvement for iron & steel industry**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Scenario 1 (Base scenario)</th>
<th>Scenario 2 (Weak scenario)</th>
<th>Scenario 3 (Strong scenario)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity input decrease (%)</td>
<td>0</td>
<td>3</td>
<td>4 (Stage 1)</td>
</tr>
<tr>
<td>Gas input decrease (%)</td>
<td>0</td>
<td>0.5</td>
<td>0.7 (Stage 2)</td>
</tr>
<tr>
<td>Investment increase (USD)</td>
<td>0</td>
<td>50.7 mil.</td>
<td>67.6 mil.</td>
</tr>
<tr>
<td>Implement time</td>
<td>-</td>
<td>2015</td>
<td>2015</td>
</tr>
</tbody>
</table>

Scenarios are provided by the technical model **FORECAST/MURE** (Forecasting Energy Consumption Analysis and Simulation Tool / Mesures d’Utilisation Rationnelle de l’Energie; Fleiter et al., 2011, 2012).
Estimated Results (1/7, base scenario)

- INFORTW estimated results of macroeconomic variables (1981 - 2025)

**Gross Domestic Production (GDP) in Taiwan**

- 1980: USD$502.7 billion
- 2025: USD$555.7 billion

**Economic Growth Rate in Taiwan**

- 2010: 2.08%
- 2015: 1.98%
INFORTW estimated results for productions of iron & steel industry (1981 - 2025)

- USD$6.75 billion
- USD$7.04 billion
Estimated Results  (3/7, impact scenario)

Energy efficiency improvement for iron & steel industry

- INFORTW estimated results for iron & steel industry

<table>
<thead>
<tr>
<th>Year</th>
<th>Scenario 2-1: Base scenario</th>
<th>Scenario 2-2: Weak scenario</th>
<th>Scenario 2-3: Strong scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production (Million USD)</td>
<td>Production changes (1000 USD)</td>
<td>Employee changes (People)</td>
</tr>
<tr>
<td></td>
<td>(People)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>6770.1</td>
<td>-524.7</td>
<td>18</td>
</tr>
<tr>
<td>2014</td>
<td>6742.8</td>
<td>-400.1</td>
<td>13</td>
</tr>
<tr>
<td>2015</td>
<td>6749.3</td>
<td>-279.2</td>
<td>12</td>
</tr>
<tr>
<td>2016</td>
<td>6780.3</td>
<td>-184.2</td>
<td>12</td>
</tr>
<tr>
<td>2017</td>
<td>6829.4</td>
<td>-110.3</td>
<td>12</td>
</tr>
<tr>
<td>2018</td>
<td>6891.8</td>
<td>-54.4</td>
<td>12</td>
</tr>
<tr>
<td>2019</td>
<td>6964.3</td>
<td>-11.1</td>
<td>11</td>
</tr>
<tr>
<td>2020</td>
<td>7044.3</td>
<td>23.2</td>
<td>11</td>
</tr>
<tr>
<td>2021</td>
<td>7129.8</td>
<td>49.1</td>
<td>10</td>
</tr>
<tr>
<td>2022</td>
<td>7219.2</td>
<td>70.2</td>
<td>10</td>
</tr>
<tr>
<td>2023</td>
<td>7310.6</td>
<td>85.0</td>
<td>10</td>
</tr>
<tr>
<td>2024</td>
<td>7405.1</td>
<td>85.0</td>
<td>10</td>
</tr>
<tr>
<td>2025</td>
<td>7501.2</td>
<td>85.0</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: The currency exchange rate (TWD/USD) is fixed at 29.6 of the 2013 value.
Estimated Results  (4/7, impact scenario)

Energy efficiency improvement for iron & steel industry

- INFORTW estimated results for Taiwan

<table>
<thead>
<tr>
<th>Year</th>
<th>Scenario 2-1: Base scenario</th>
<th>Scenario 2-2: Weak scenario</th>
<th>Scenario 2-3: Strong scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP (Million USD)</td>
<td>GDP changes (Million USD)</td>
<td>GDP changes (Million USD)</td>
</tr>
<tr>
<td></td>
<td>Growth rate (%)</td>
<td>Employee changes (People)</td>
<td>Employee changes (People)</td>
</tr>
<tr>
<td>2013</td>
<td>482303.7</td>
<td>182.83</td>
<td>243.83</td>
</tr>
<tr>
<td>2014</td>
<td>492473.0</td>
<td>207.01</td>
<td>275.93</td>
</tr>
<tr>
<td>2015</td>
<td>502732.4</td>
<td>180.05</td>
<td>290.70</td>
</tr>
<tr>
<td>2016</td>
<td>513113.3</td>
<td>167.00</td>
<td>298.54</td>
</tr>
<tr>
<td>2017</td>
<td>523604.5</td>
<td>1700</td>
<td>302.65</td>
</tr>
<tr>
<td>2018</td>
<td>534195.1</td>
<td>1719</td>
<td>302.65</td>
</tr>
<tr>
<td>2019</td>
<td>544886.1</td>
<td>1723</td>
<td>302.65</td>
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<tr>
<td>2020</td>
<td>555693.1</td>
<td>1719</td>
<td>302.65</td>
</tr>
<tr>
<td>2021</td>
<td>566650.8</td>
<td>1696</td>
<td>302.65</td>
</tr>
<tr>
<td>2022</td>
<td>577798.1</td>
<td>1641</td>
<td>302.65</td>
</tr>
<tr>
<td>2023</td>
<td>589213.0</td>
<td>1556</td>
<td>302.65</td>
</tr>
<tr>
<td>2024</td>
<td>600898.1</td>
<td>1514</td>
<td>302.65</td>
</tr>
<tr>
<td>2025</td>
<td>612940.7</td>
<td>1514</td>
<td>302.65</td>
</tr>
</tbody>
</table>

Note: The currency exchange rate (TWD/USD) is fixed at 29.6 of the 2013 value.
Estimated Results  (5/7, impact scenario)

- Production changes due to energy efficiency improvement in iron & steel industry

6 years of recovery

Multiplier = $\Delta GDP/\Delta I = 4$

$\Delta GDP = +536$
$\Delta I = +135.2$

$\Delta GDP = +198$
$\Delta I = +50.7$
Estimated Results (6/7, impact scenario)

- **Employee changes** due to energy efficiency improvement in iron & steel industry

![Graph showing employee changes](image)

(A) Employee changes for iron & steel industry

(B) Total employee changes in Taiwan

- Weak scenario
- Strong scenario: Stage 1
- Strong scenario: Stage 2
Estimated Results (7/7, results review)

- Investments in the energy efficiency improvement for the iron and steel industry
  - Has positive effects on Taiwan’s GDP & labor market
  - The multiplier of the investment is nearly 4 times
  - Due to the 6 years recovery period, the iron and steel industry has less incentive to invest in the short term
Conclusion (1/2)

- Develops the model INFORTW
  - Contains real side & price-income side
  - Employs I–O tables, national accounts & RAS method

- Impact simulations
  - Energy efficiency improvement for iron & steel industry
Conclusion (2/2)

- Further research
  - Maintaining
    - 2011 I–O table updates (released in mid-2014)
    - Further annual data collected
  - Extending
    - Energy module
    - ‘Green’ industry module
    - Detailed industry module
Thank you 😊

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