Issues in Panel Data Model Selection: The Case of Empirical Analysis of Demand for Reinsurance

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Introduction

- Australian data on demand for reinsurance
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• Panel data methodology and models
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- Choice of OLS with Panel-Corrected Standard Errors
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- Panel data methodology and models
- Choice of OLS with Panel-Corrected Standard Errors
- Results from the study
Australian Data

- APRA data 1996-2001 - general insurers and reinsurers
Australian Data

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- Panel dataset - 98 insurers and 543 observations
Australian Data

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- Panel dataset - 98 insurers and 543 observations
- 70% of all insurers in 2001 by asset value
Australian Data

- Reinsurance demand - ration of reinsurance expense to total premium revenue (REINS);
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- Leverage - ratio of total liabilities to total assets (LEV);
- Size - logarithm of total asset value (LnSIZE)
Australian Data

- Reinsurance demand - ration of reinsurance expense to total premium revenue (REINS);
- Leverage - ratio of total liabilities to total assets (LEV)
- Size - logarithm of total asset value (LnSIZE)
- Tax - ratio of tax expense to total premiums (TAX)
Australian Data

- Expected effects and reasons
  - Reinsurance demand (REINS) and leverage (LEV); more leverage, less capital, more reinsurance (+ive)
  - Reinsurance demand (REINS) and Size (Ln Size); larger insurer, less reinsurance (-ive)
  - Reinsurance demand (REINS) and Tax (TAX); lower tax, more reinsurance (-ive)
  - Reinsurance demand (REINS) and Return (INVEST); more investment income, more risky, less reinsurance (-ive)
Australian Data

<table>
<thead>
<tr>
<th></th>
<th>Max.</th>
<th>Min.</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev.</th>
<th>Skewness</th>
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<tr>
<td><strong>Reinsurance</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ratio</td>
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<td>0</td>
<td>0.28238</td>
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<td>(REINS)</td>
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<tr>
<td><strong>Leverage</strong></td>
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<tr>
<td>(LEV)</td>
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<td><strong>Size</strong></td>
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<tr>
<td>(LnSIZE)</td>
<td>15.90520</td>
<td>6.04500</td>
<td>11.36361</td>
<td>11.37034</td>
<td>1.85927</td>
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<td><strong>Tax Ratio</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(TAX)</td>
<td>6.9625</td>
<td>-2.05180</td>
<td>0.10153</td>
<td>0.01834</td>
<td>0.47182</td>
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<td></td>
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<td></td>
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<td>Investment</td>
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<td>-0.20990</td>
<td>0.08428</td>
<td>0.06781</td>
<td>0.10275</td>
<td>5.13779</td>
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<tr>
<td>(INVEST)</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Reinsurance vs. Size

Graphs by year

- 1996
- 1997
- 1998
- 1999
- 2000
- 2001

Size (ln of total asset value)

Reinsurance Ratio

Graphs by year
Reinsurance vs. Leverage

Graphs by year

1996

1997

1998

1999

2000

2001

Reinsurance Ratio

Leverage
Reinsurance vs. Taxes

Graphs by year
Reinsurance vs. Investment Return

Graphs by year

1996
1997
1998
1999
2000
2001
Panel Data Methodology and Models

• Allowed for
  • Year Dummy Variables
  • Groups of Companies
  • Reinsurers
Panel Data Methodology and Models

- Allowed for
  - Year Dummy Variables
  - Groups of Companies
  - Reinsurers
- Need for careful modelling
  - Standard regression assumptions do not hold
  - Spurious results if not properly modelled
Panel Data Methodology, and Models

\[ y_{i,t} = \beta_1 x_{it,1} + \beta_2 x_{it,2} + \cdots + \beta_K x_{it,K} + \epsilon_{i,t} \]  

(1)

\[ i = 1, 2, \ldots N \] observation units, \( t = 1, 2, \ldots T \) time periods, and \( k = 1, \ldots K \) explanatory variables

Grouping all time periods \( t = 1, 2, \ldots T \) we get

\[ y_i = X_i \beta + \epsilon_i \]  

(2)
Panel Data Methodology, and Models

\[ \beta^* = \left( \sum_{i=1}^{N} X_i' \Omega^{-1} X_i \right)^{-1} \left( \sum_{i=1}^{N} X_i' \Omega^{-1} y_i \right) \]  \hspace{1cm} (3)

\[ \Omega = I_T \otimes \Sigma = \begin{pmatrix} \Sigma & 0 & \cdots & 0 \\ 0 & \Sigma & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \Sigma \end{pmatrix} \]

\[ \Sigma = \begin{pmatrix} \sigma_1^2 & \sigma_{12} & \cdots & \sigma_{1N} \\ \sigma_{21} & \sigma_2^2 & \cdots & \sigma_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{N1} & \sigma_{N2} & \cdots & \sigma_N^2 \end{pmatrix} \]

Panel heteroscedasticity: \( E[\epsilon_{it}^2] \neq E[\epsilon_{jt}^2] \) but \( E[\epsilon_{it}^2] = E[\epsilon_{is}^2] \)

Contemporaneously correlated errors:

\( E[\epsilon_{it}\epsilon_{jt}] = E[\epsilon_{is}\epsilon_{js}] \neq 0, \) but \( E[\epsilon_{it}\epsilon_{js}] = 0 \)
Panel Data Methodology, and Models

Random Effects and Fixed Effects Specification

\[ y_{it} = x_{it} + c_i + u_{it} \quad t = 1, 2, \ldots, T \quad (4) \]

\[ \Omega = E(v_i v_i') = \begin{pmatrix} \sigma_c^2 + \sigma_u^2 & \sigma_c^2 & \ldots & \sigma_c^2 \\ \sigma_c^2 & \sigma_c^2 + \sigma_u^2 & \ldots & \sigma_c^2 \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_c^2 & \sigma_c^2 & \ldots & \sigma_c^2 + \sigma_u^2 \end{pmatrix} \]
Panel Data Methodology, and Models

OLS with Panel Corrected Standard Errors:

If errors present panel heteroskedasticity and contemporaneous correlation, then OLS estimates of $\beta$ are inefficient. However they are still consistent.

we can use the OLS residuals to obtain a consistent estimate of $\Sigma$.

Let $e_{i,t}$ the OLS residual for unit $i$ at time $t$. An element of $\Sigma$ can now be estimated by

$$\hat{\Sigma}_{i,j} = \frac{\sum_{t=1}^{T} e_{i,t}e_{j,t}}{T}$$

(5)
### Results OLS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimates</th>
<th>Standard Errors</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$LEV$</td>
<td>0.373</td>
<td>0.046</td>
<td>8.00</td>
<td>0.000***</td>
</tr>
<tr>
<td>$LnSIZE$</td>
<td>-0.027</td>
<td>0.007</td>
<td>-3.65</td>
<td>0.000***</td>
</tr>
<tr>
<td>$TAX$</td>
<td>0.005</td>
<td>0.023</td>
<td>0.22</td>
<td>0.829</td>
</tr>
<tr>
<td>$INVEST$</td>
<td>0.082</td>
<td>0.108</td>
<td>0.76</td>
<td>0.448</td>
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<tr>
<td>$D_{group}$</td>
<td>-0.006</td>
<td>0.033</td>
<td>-0.18</td>
<td>0.858</td>
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<tr>
<td>$D_{reinsurer}$</td>
<td>0.009</td>
<td>0.041</td>
<td>0.23</td>
<td>0.821</td>
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<tr>
<td>$D_{1997}$</td>
<td>0.018</td>
<td>0.039</td>
<td>0.46</td>
<td>0.643</td>
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<tr>
<td>$D_{1998}$</td>
<td>0.004</td>
<td>0.040</td>
<td>0.11</td>
<td>0.915</td>
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<tr>
<td>$D_{1999}$</td>
<td>-0.002</td>
<td>0.039</td>
<td>-0.07</td>
<td>0.948</td>
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<tr>
<td>$D_{2000}$</td>
<td>0.019</td>
<td>0.040</td>
<td>0.49</td>
<td>0.623</td>
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<tr>
<td>$D_{2001}$</td>
<td>0.336</td>
<td>0.080</td>
<td>4.16</td>
<td>0.000***</td>
</tr>
<tr>
<td>$Const$</td>
<td>0.336</td>
<td>0.080</td>
<td>4.16</td>
<td>0.000</td>
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</table>
## Results Random Effects

<table>
<thead>
<tr>
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<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEV</td>
<td>0.030</td>
<td>0.031</td>
<td>0.97</td>
<td>0.334</td>
</tr>
<tr>
<td>LnSIZE</td>
<td>0.031</td>
<td>0.010</td>
<td>3.06</td>
<td>0.002***</td>
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<tr>
<td>TAX</td>
<td>0.010</td>
<td>0.009</td>
<td>1.08</td>
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<tr>
<td>INVEST</td>
<td>0.035</td>
<td>0.052</td>
<td>0.67</td>
<td>0.503</td>
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<tr>
<td>D_group</td>
<td>-0.130</td>
<td>0.058</td>
<td>-2.23</td>
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<tr>
<td>D_reinsurer</td>
<td>-0.014</td>
<td>0.079</td>
<td>-0.18</td>
<td>0.858</td>
</tr>
<tr>
<td>D_1997</td>
<td>-0.004</td>
<td>0.014</td>
<td>-0.30</td>
<td>0.762</td>
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<tr>
<td>D_1998</td>
<td>0.002</td>
<td>0.014</td>
<td>0.16</td>
<td>0.877</td>
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<tr>
<td>D_1999</td>
<td>0.001</td>
<td>0.014</td>
<td>0.09</td>
<td>0.926</td>
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<tr>
<td>D_2000</td>
<td>-0.007</td>
<td>0.014</td>
<td>-0.53</td>
<td>0.600</td>
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<tr>
<td>D_2001</td>
<td>0.004</td>
<td>0.015</td>
<td>0.29</td>
<td>0.773</td>
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<tr>
<td>Const</td>
<td>-0.028</td>
<td>0.107</td>
<td>-0.26</td>
<td>0.791</td>
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### Results OLS with PCSE

<table>
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<tr>
<th>Variable</th>
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<th>Standard Errors</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$LEV$</td>
<td>0.100</td>
<td>0.051</td>
<td>1.96</td>
<td>0.050**</td>
</tr>
<tr>
<td>$LnSIZE$</td>
<td>-0.004</td>
<td>0.010</td>
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<td>0.641</td>
</tr>
<tr>
<td>$TAX$</td>
<td>-0.001</td>
<td>0.007</td>
<td>-0.16</td>
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<tr>
<td>$INVEST$</td>
<td>0.026</td>
<td>0.049</td>
<td>0.55</td>
<td>0.585</td>
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<tr>
<td>$D_{group}$</td>
<td>-0.058</td>
<td>0.038</td>
<td>-1.52</td>
<td>0.129</td>
</tr>
<tr>
<td>$D_{reinsurer}$</td>
<td>-0.016</td>
<td>0.049</td>
<td>-0.34</td>
<td>0.733</td>
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<tr>
<td>$D_{1997}$</td>
<td>-0.000</td>
<td>0.005</td>
<td>-0.11</td>
<td>0.912</td>
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<tr>
<td>$D_{1998}$</td>
<td>0.004</td>
<td>0.006</td>
<td>0.79</td>
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<td>$D_{1999}$</td>
<td>0.005</td>
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<tr>
<td>$Const$</td>
<td>0.298</td>
<td>0.103</td>
<td>2.89</td>
<td>0.004***</td>
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</table>
Results from Study - OLS with PCSE

- Significance of leverage (capital) and link to demand for reinsurance
Results from Study - OLS with PCSE

- Significance of leverage (capital) and link to demand for reinsurance
- Lack of statistical significance of size, tax, return, group, reinsurer
Results from Study - OLS with PCSE

- Significance of leverage (capital) and link to demand for reinsurance
- Lack of statistical significance of size, tax, return, group, reinsurer
- Although not significant, negative effect of size, tax, group and reinsurer and increasing time trend
Summary

- Study confirms role of reinsurance in insurer capital and risk management
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• As far as we are aware, the first empirical study of demand for reinsurance in Australia
• Study addresses important issues in methodology for studies in this area (panel data, model assumptions)
• Need for better data