The Cross-Section of Asia-Pacific Mortality Dynamics: Implications for Longevity Risk Sharing

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September 2014
Longevity 10 Conference
Santiago, Chile
Outline of Presentation

1. Motivation
2. Data Collection Exercise
3. Descriptive Statistics
4. Methodology (Multi-population)
5. Why does Longevity Risk Sharing make sense?
6. Results
7. Longevity Hedge Example
8. Conclusion
1. Motivation

Asia-Pacific (APAC) is important for Longevity Risk Management for the following reasons:

• Market development
  – Longevity Risk Market is less developed in APAC than Europe and North America.
  – Several APAC countries are young and emerging with different population structures than the more developed countries.
  – Insurance growth in the largest regions (i.e. China and India) has double digit growth (according to a 2013 IRFRC project)
1. Motivation

• Multi-population modelling and risk sharing:
  – Most insurance instruments target issuer’s own mortality/longevity risk.
  – This may present a barrier to standardization and liquidity.
  – Opportunities for risk pooling, indexation and diversification across more than one population.
  – Identification of cross-sectional longevity risk opportunities in APAC.
  – Interaction of APAC heterogeneity with more developed markets.
1. Motivation

Data Scarcity in APAC:

• IMF (2012):
  – Use data and projections from UN database.
  – Demographic changes present challenge to the sustainability of social security systems and global growth, e.g.:
    – Old-age dependency in
      • Developed countries: to double from 2010-2050 (24 to 48%)
      • Emerging countries: to ~triple from 2010-2050 (13 to 36%)
  – Projections conditional on data and uncertainty in longevity risk.
1. Motivation

Our contributions:

1. Hand-collected mortality data from Asia-Pacific (APAC)
   – Asia-Pacific Age Gender (APAG) Mortality Database

2. First look into the cross-section of APAC mortality risk to identify static and dynamic factors in multi-population mortality.

3. Longevity cross-sectional Risk Sharing opportunities within APAC.
2. Data Collection Exercise

- **Target Countries**: 21 countries in APAC
- **Data collection process**:
  - Identified data sources from academic papers
  - Identified data sources from industry papers
- **Leading Databases** (not sufficient):
  - The Human Mortality Database (HMD)
  - The Human Life-Table Database (HLT)
- **Complementary Databases**
  - Countries’ Official Sources
- **Data Cleaning, Testing, Quality**.
# 2. Data Collection Exercise
## Target Countries

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<th>DEVELOPED</th>
<th>REGION</th>
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## 2. Data Collection Exercise
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<th>REGION</th>
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<td>Guinea</td>
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<td>Singapore</td>
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<td>Sri Lanka</td>
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<td>Taiwan</td>
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<td>Thailand</td>
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<tr>
<td>Vietnam</td>
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</tbody>
</table>
2. Data Collection Exercise

• Identified sources from papers and presentations:
  – JRI, IME, NAAJ, ASTIN, SAJ, etc.

• Keywords used:
  – “mortality, data, country name”
  – “longevity, data and country name”

• More than 200 papers/presentations identified.

• Only 34 papers for APAC which used data from HMD & HLT (e.g. Japan, Taiwan, Australia).
2. Data Collection Exercise

Main Data Sources (additional to HMD and HLT)

- Department of Statistics,
- Ministry of Health,
- Statistical Yearbooks, Censuses (for each country)
- Sample registration system (SRS) – India
- World Bank
- Vital Registration systems
- Population studies journal
- Measure DHS (Demographic and health surveys)
- Global Health Data Exchange
- International Database on Longevity (IDL)
2. Data Collection Exercise

• Resulted in 2 databases, which are being analysed in the following projects:

1. Asia-Pacific Aggregate (APA) Mortality Database
   • Milidonis and Efthymiou, 2014

2. Asia-Pacific Age-Gender (APAG) Mortality Database
   • Biffis, Lin & Milidonis, 2014

• Both databases freely available for future research from the Insurance Risk & Finance Research Centre, Nanyang Business School, NTU
For ease of reference the following color representations are used:

- **HMD**
- **HLT**
- **Bureau of Statistics**
- **Censuses**
- **Ministry of Health**
- **Sample registration system (India)**
APAG Mortality Database
APAG Mortality Database

- Originally 11 countries with > 20 years of data

- Decided to start with a **balanced panel**:
  - 8 countries
  - 1980-2010 (Continuous data)
  - 15 five-year age groups (0-4; 5-9; ... 70-75).
  - Females first; Males follow.
  - Age-specific *Death Probabilities*.
  - Age-specific Crude Death rates also available.
  - We follow HMD methodology to make any transformations where necessary.
## 3. Descriptive Statistics

### Country abbreviations

<table>
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<th>Country</th>
<th>Code</th>
<th>Region</th>
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<td>AUS</td>
<td>Oceania</td>
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<td>2</td>
<td>Hong Kong</td>
<td>HKG</td>
<td>East Asia</td>
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<td>3</td>
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<td>6</td>
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</tr>
<tr>
<td>8</td>
<td>Taiwan</td>
<td>TWN</td>
<td>East Asia</td>
</tr>
</tbody>
</table>
Average Mortality by Age and Countries
APAG (Females: 1950 - 2012)
Mortality by Country, Female, Age 55
APAG (Females: 1950 - 2012)
Mortality by Country, Female, Age 60 APAG (Females: 1950 - 2012)
Mortality by Country, Female, Age 65
APAG (Females: 1950 - 2012)
Mortality by Age and Regions
APAG (Females: 1950 - 2012)
Mortality by region, Female, Age 55
APAG (Females: 1950 - 2012)
Mortality by region, Female, Age 60
APAG (Females: 1950 - 2012)
Mortality by region, Female, Age 65
APAG (Females: 1950 - 2012)
Mortality by Year, Age: *East Asia*
APAG (Females: 1950 - 2012)
Mortality by Year, Age: *Oceania*  
APAG (Females: 1950 - 2012)
Mortality by Year, Age: South-East Asia
APAG (Females: 1950 - 2012)
4. Methodology

• Exploratory Analysis of the 8 countries using 2 approaches:

1. A heuristic approach (Li and Lee, 2005) on major geographical regions to identify:
   i. Common time-series factor
   ii. Country-specific time-series factors
   iii. Age Loadings (region-wide and country-specific)

2. An “agnostic” approach to identify relevant factors using:
   i. Static Factor model of Bai & Ng (2002) and Alessi et al. (2006).
   ii. General Dynamic Factor model of Forni et al. (2005) and Hallin and Liska (2007).
4. Methodology

An “agnostic” approach to identify relevant factors:

- Common factors are static: they have contemporaneous impact on death probabilities; but they are dynamic as a lag structure is assumed.
- Idiosyncratic shocks can be correlated but need to be stationary.
- GDFM is called approximate factor model as the common factors are loaded onto the variables with a finite lag structure & the idiosyncratic components can be weakly correlated.
- Error terms are assumed to be GARCH(1,1) but they can take other forms.
- Alessi et al. (2006) and Hallin & Liska (2007) used to select the number of factors.
4. Methodology

- Li and Lee (2005)

\[ \ln q(x, i, t) = B(x)K(t) + a(x, i) + b(x, i)k(t, i) + \varepsilon(x, i, t) \]

\[ K(t) = c + K(t-1) + \sigma_K e(t), \quad e(t) \sim N(0,1) \]

\[ k(t, i) = r_{0,i} + r_{1,i} k(t-1, i) + \sigma_{k,i} e_i(t), \quad e_i(t) \sim N(0,1) \]
4. Methodology

- Two Agnostic Models:
  - Static Factor model of Bai & Ng (2002) and Alessi, et al. (2006).
  - Gen. Dynamic Factor Model (Forni et al. (2005) and Hallin & Liska, 2007).

- Agnostic: we let the model pick the factors and do not impose any constraints besides those dictated by the model (which are less binding than the Li and Lee model).

- Used different combinations of the 8 countries.

- Results provide support to the idea that Japan is quite different than the rest and that Hong Kong is also quite rich in terms of heterogeneity.
5. Why does Longevity Risk Sharing make sense?

- Results from the “agnostic” factor approach (Alessi et al. 2007) provide support for using Li and Lee (2005)’s heuristic approach for some subsets of countries.

- Using Li and Lee (2005), we identify:
  - a **downward** trending common risk factor \((K(t))\)
  - a **downward** trending factor for country A, \((k(A,t))\)
  - An **upward** trending factor for country B, \((k(B,t))\) among others.

- This set up **provides incentives for longevity risk hedging** between countries A and B.
5. Why does Longevity Risk Sharing make sense?

- We may think of longevity risk as:

  \[ \text{Total Risk} = \text{Common Risk} + \text{Country Risk} \]

- **Common Risk** = common risk factor, \( K(t) \)
- **Country Risk** = country-specific factors, \( k(i,t) \)

- Since some pairs of countries may have opposite signs on the country-specific component, then they could enter a trading mechanism to **hedge their country-specific risk exposures**.
6. Results

Li and Lee (2005):

- East Asia:
  - Hong-Kong, Japan, Korea & Taiwan.

- Oceania:
  - Australia & New Zealand.

- South-East Asia:
  - Singapore & Philippines.
6. Results

EAST ASIA: Mortality Time-Series Evolution (Li and Lee, 2005)
6. Results

EAST ASIA: Mortality Time-Series Evolution (Li and Lee, 2005)

- $K(t)$
- $k_{(JAP,t)}$
- $k_{(KOR,t)}$
7. Longevity Hedge Example

Example: 20-year Temporary Life Annuity-Due

- Female Age 55 in Japan
- Female Age 55 in Korea
- $1 at the end of every year upon survival.
- Start year: 2010
- Interest rate: 0%
7. Longevity Hedge Example

Example: 20-year Temporary Life Annuity-Due

- 20-year forecast of $K(t)$, $k(JAP, t)$ and $k(KOR, t)$.

- Simulations based on each series’ historical trends.

- We examine three scenarios:
  - Baseline: Mean Forecasted Value
  - Negative Deviation: 10th percentile of $K(t)$
  - Positive Deviation: 90th percentile of $K(t)$
7. Longevity Hedge Example

- Results show opposite, country-specific effects between KOR and JAP.
  - KOR: Country risk moves in parallel to $K(t)$
  - JAP: Country risk moves opposite to $K(t)$

- Incentive to trade country risk using opposite hedging positions.
  - Traded index: $K(t)$
  - Exposure: Pension plan in JAP & KOR.
  - Contract date: $(t)$
  - APV estimation at: $(t+1)$
### 7. Longevity Hedge Example

<table>
<thead>
<tr>
<th>K(t) Index</th>
<th>Instrument</th>
<th>JAP (long)</th>
<th>KOR (short)</th>
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<tr>
<td><strong>Up</strong></td>
<td>Pensions:</td>
<td>More at (t+1)</td>
<td>Less at (t+1)</td>
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<td>Forward:</td>
<td>Gain</td>
<td>Loss</td>
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<tr>
<td><strong>Down</strong></td>
<td>Pensions:</td>
<td>Less at (t+1)</td>
<td>More at (t+1)</td>
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<td>Forward:</td>
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<td>Gain</td>
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7. Example: Why does longevity risk transfer make sense?

Example: 20-year Temporary Life Annuity-Due

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<td></td>
<td>Base</td>
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<td>Base</td>
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<td>APV (with Total Risk)</td>
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<td>$16.50</td>
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<td>APV (with Common Risk only)</td>
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<td>% of Country to Total Risk</td>
<td>168%</td>
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Future Research

• Additional analysis within APAC

• Interactions between developed and emerging markets.

• Robustness results using prevalent factors from the “agnostic approach”.
8. Conclusion

- We present a new, hand-collected dataset of Age-Gender mortality for Asia-Pacific (APAC).
- Exploratory approach into a heterogeneous region.
- Multi-population Factor analysis using heuristic and agnostic approaches.
- Treat longevity risk into “common risk” and “country-specific” risk reveals hedging opportunities.
- Hedging focused on opposite direction of country risk.

*Data available for future research from IRFRC.*
Feedback welcome:

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