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

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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

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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)

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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.

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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.

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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.

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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

	DEVELOPED			REGION				
Country	Yes	Less	Least	Australia/ New Zealand	Melanesia	Eastern Asia	South-Central Asia	South-Eastern Asia
Australia	√			√				
Bangladesh			√				√	
China		√				√		
Hong Kong		√				√		
India		√					√	
Indonesia		√						√
Japan	√					√		
Laos			√					√
Malaysia		√						√
Myanmar			√					√
Nepal			√				√	

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2. Data Collection Exercise Target Countries

	DEVELOPED			REGION				
Country	Yes	Less	Least	Australia /New Zealand	Melanesia	Eastern Asia	South-Central Asia	South-Eastern Asia
New Zealand	√			√				
Pakistan		√					√	
Papua New Guinea		√			√			
Philippines		√						√
South Korea		√				√		
Singapore		√						√
Sri Lanka		√					√	
Taiwan	√					√		
Thailand		√						√
Vietnam		√						√

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2. Data Collection Exercise

- Identified sources from papers and presentations:
  - JRI, IME, NAAJ, ASTIN, SAJ, etc.
  - Presentations from the International Longevity Risk and Capital Market Solutions Conference 2011-2013.
- 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)*

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2. Data Collection Exercise

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

1. **A**sia-**P**acific **A**ggregate (**APA**) Mortality Database
   - Milidonis and Efthymiou, 2014

2. **A**sia-**P**acific **A**ge-**G**ender (**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**

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APAG Mortality Database

For ease of reference the following color representations are used:

- HMD
- HLT
- Bureau of Statistics
- Censuses
- Ministry of Health
- Sample registration system (India)

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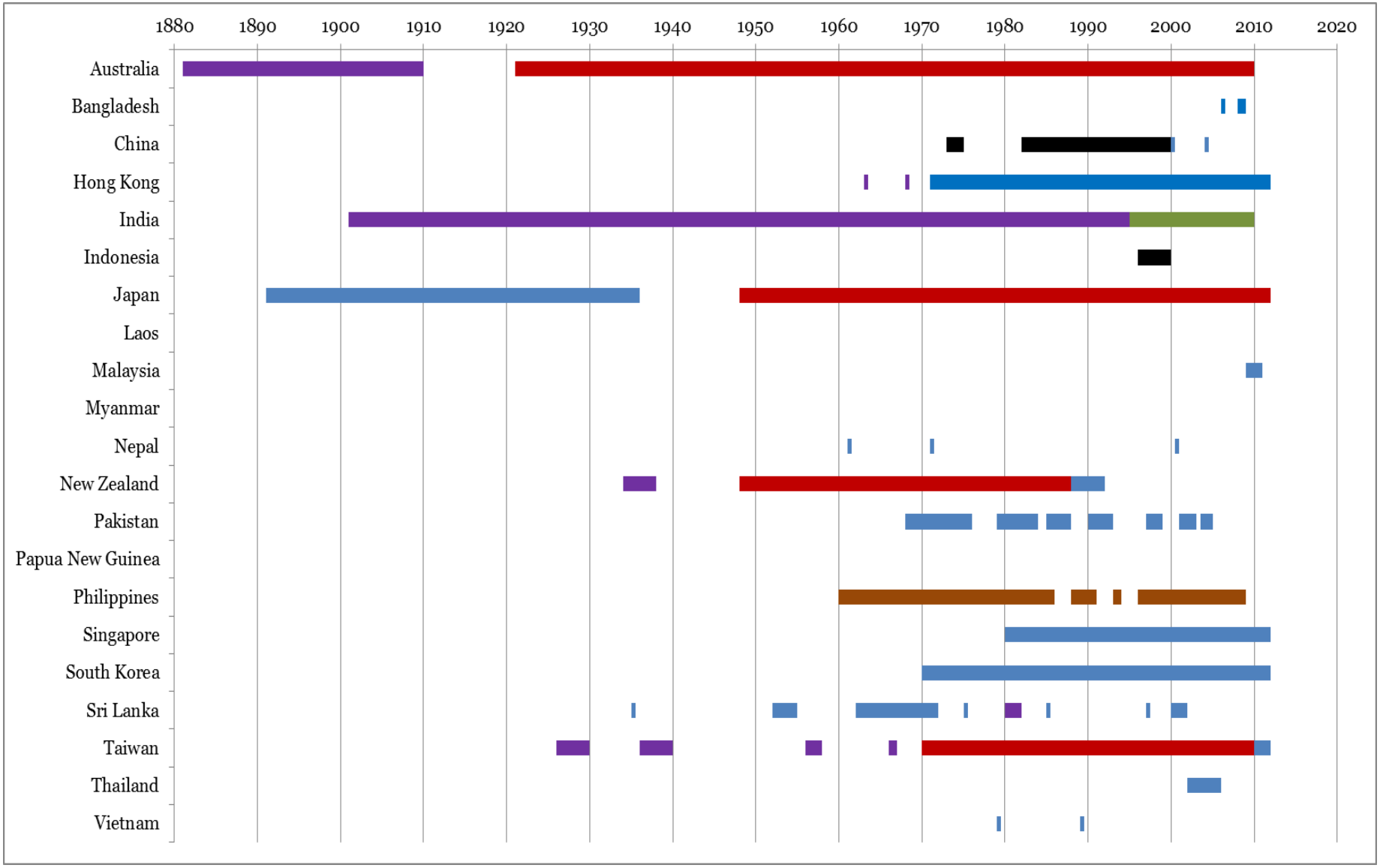
APAG Mortality Database



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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.

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3. Descriptive Statistics

Country abbreviations

No	Country	Code	Region
1	Australia	AUS	Oceania
2	Hong Kong	HKG	East Asia
3	Japan	JPN	East Asia
4	Republic of Korea	KOR	East Asia
5	New Zealand	NZL	Oceania
6	Philippines	PHL	South-East Asia
7	Singapore	SGP	South-East Asia
8	Taiwan	TWN	East Asia

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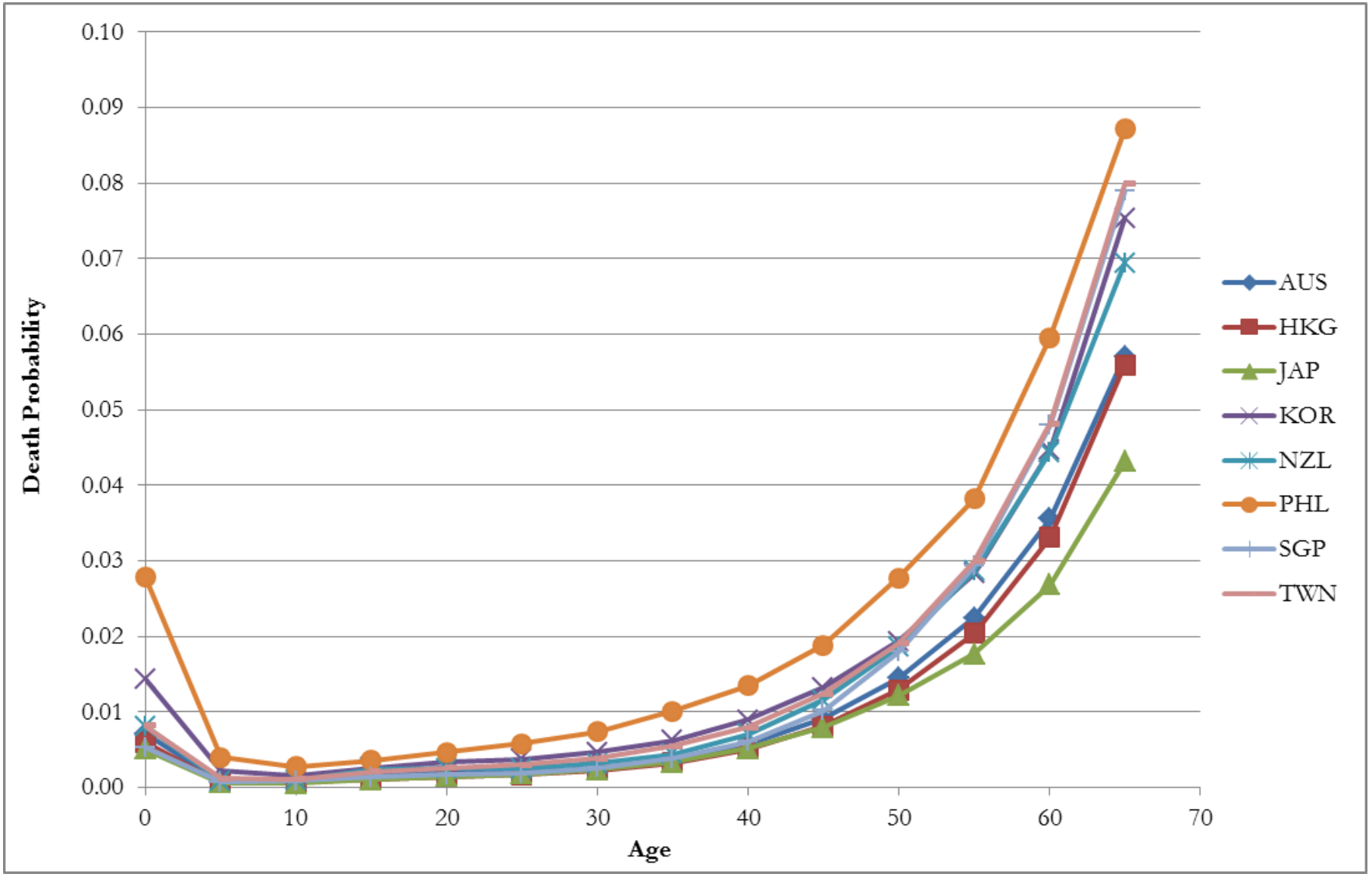
Average Mortality by Age and Countries APAG (Females: 1950 - 2012)



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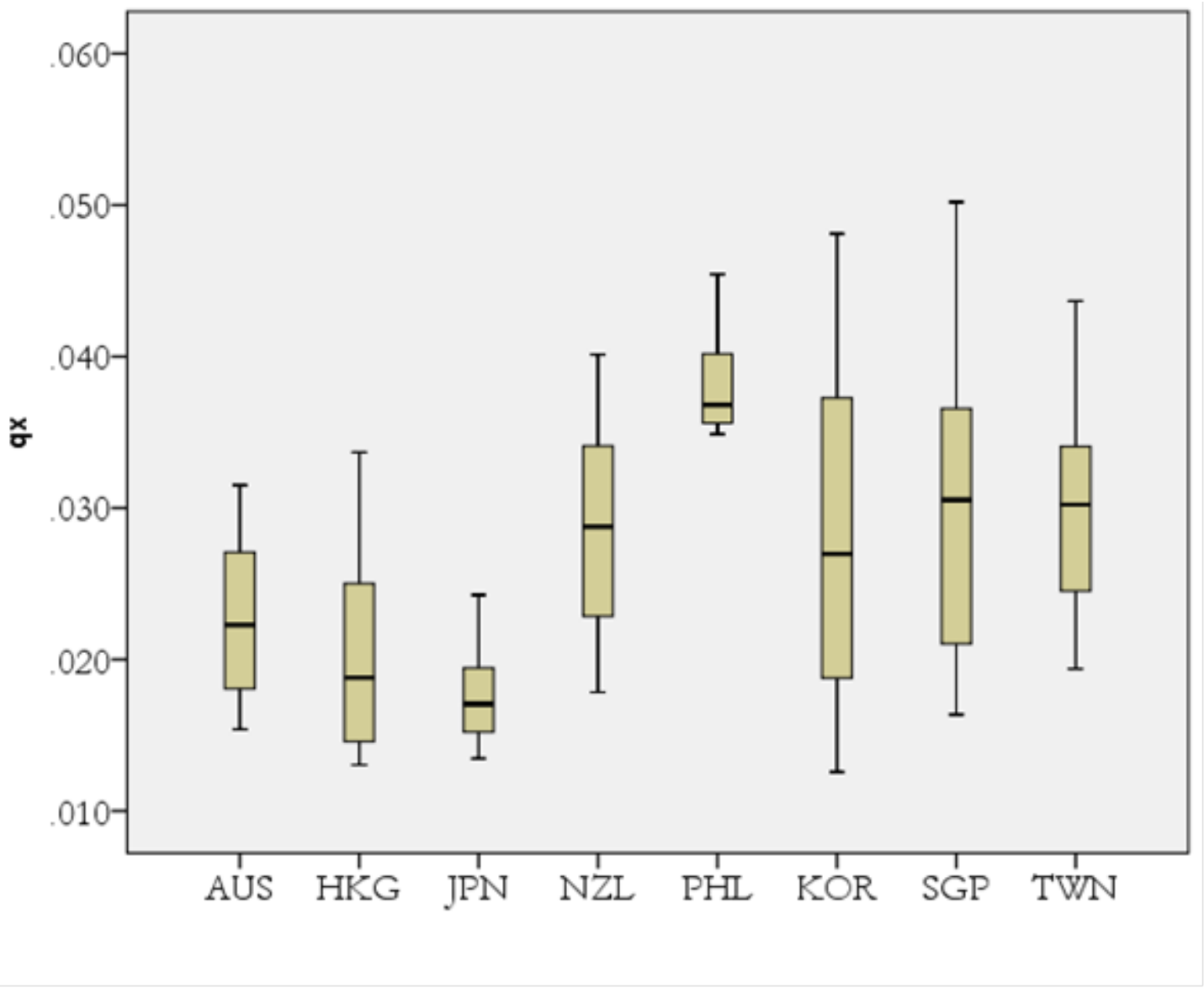
Mortality by Country, Female, Age *55*
APAG (Females: 1950 - 2012)



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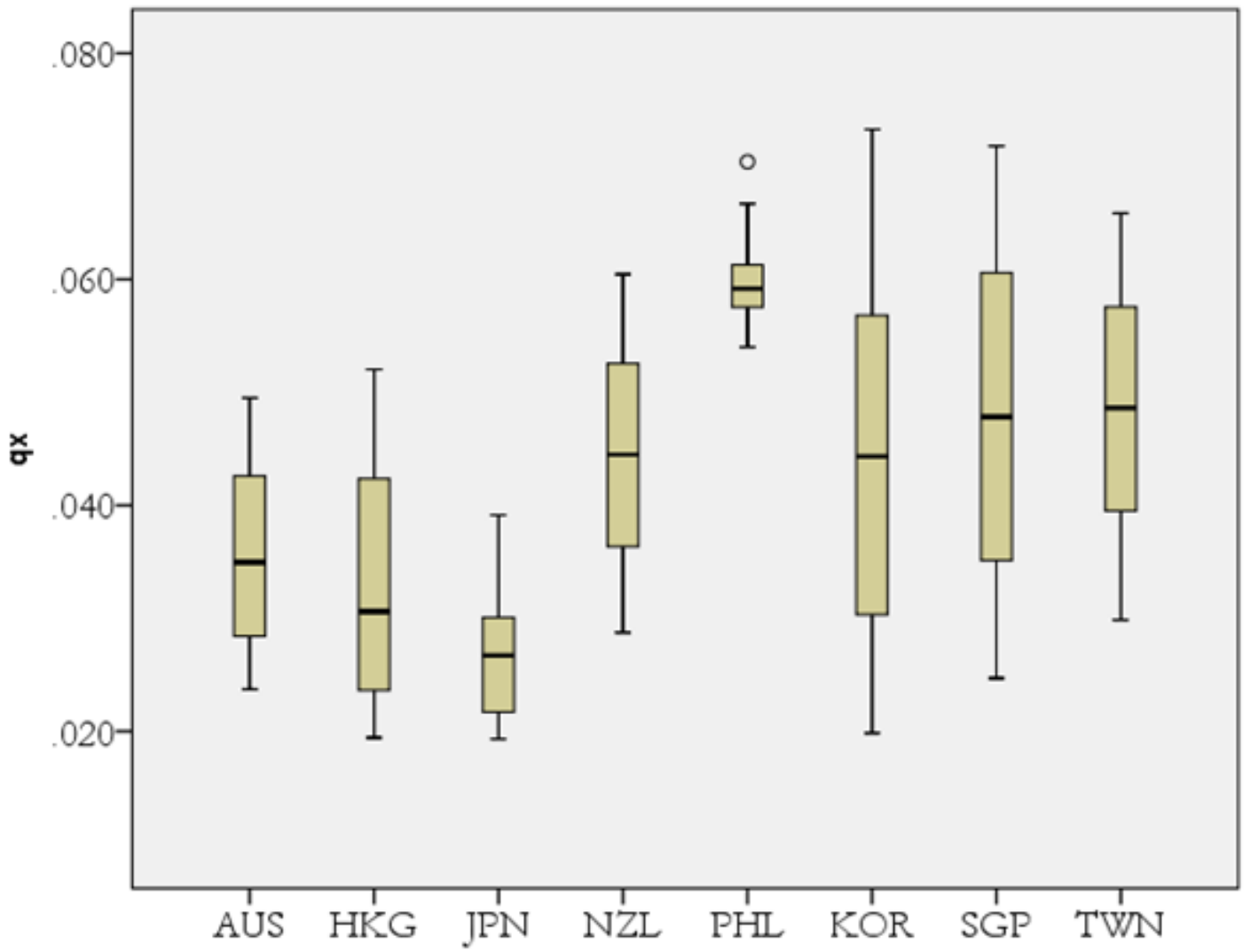
Mortality by Country, Female, Age *60*
APAG (Females: 1950 - 2012)



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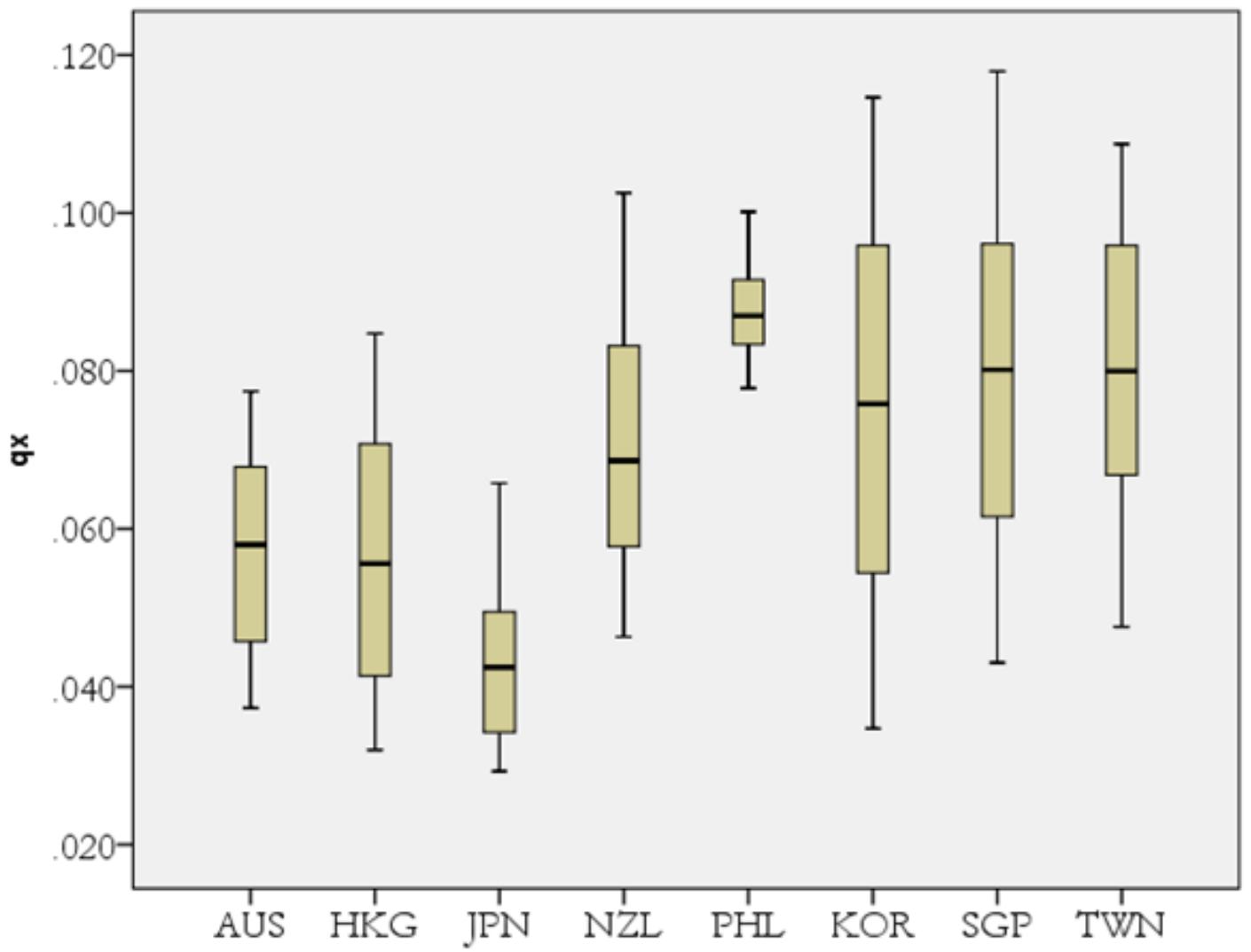
Mortality by Country, Female, Age *65*
APAG (Females: 1950 - 2012)



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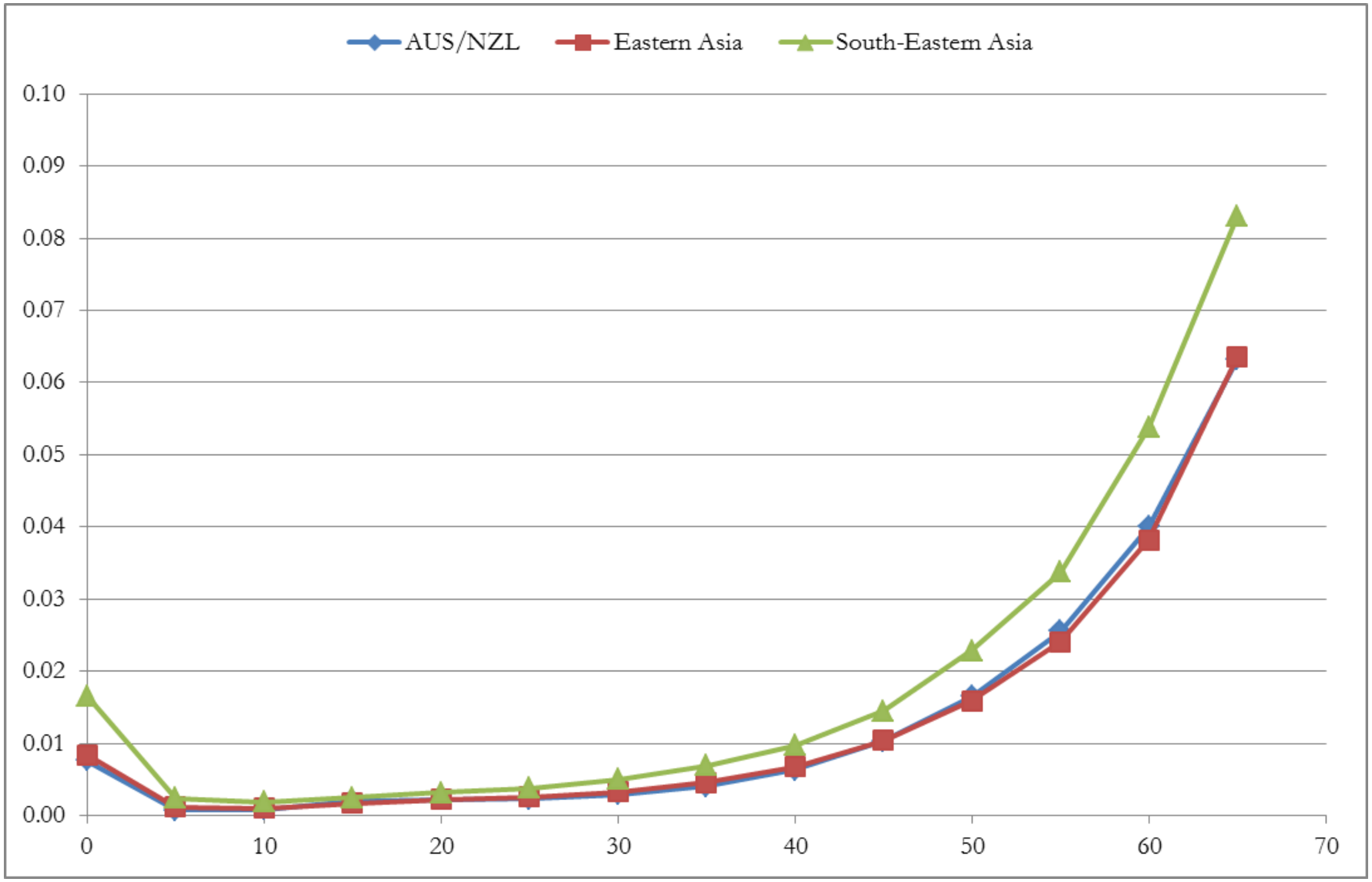
Mortality by Age and Regions
APAG (Females: 1950 - 2012)



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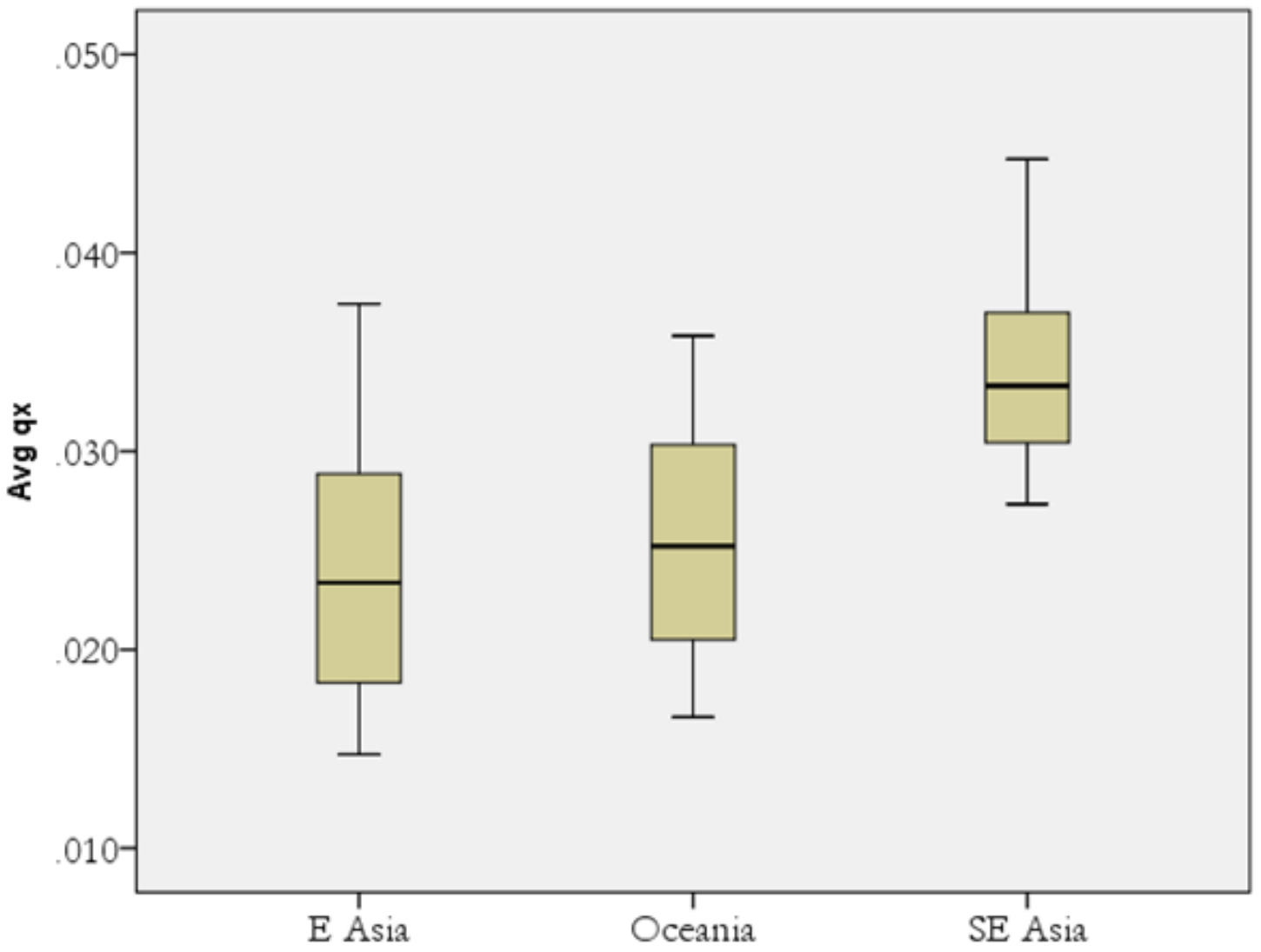
Mortality by region, Female, Age *55*
APAG (Females: 1950 - 2012)



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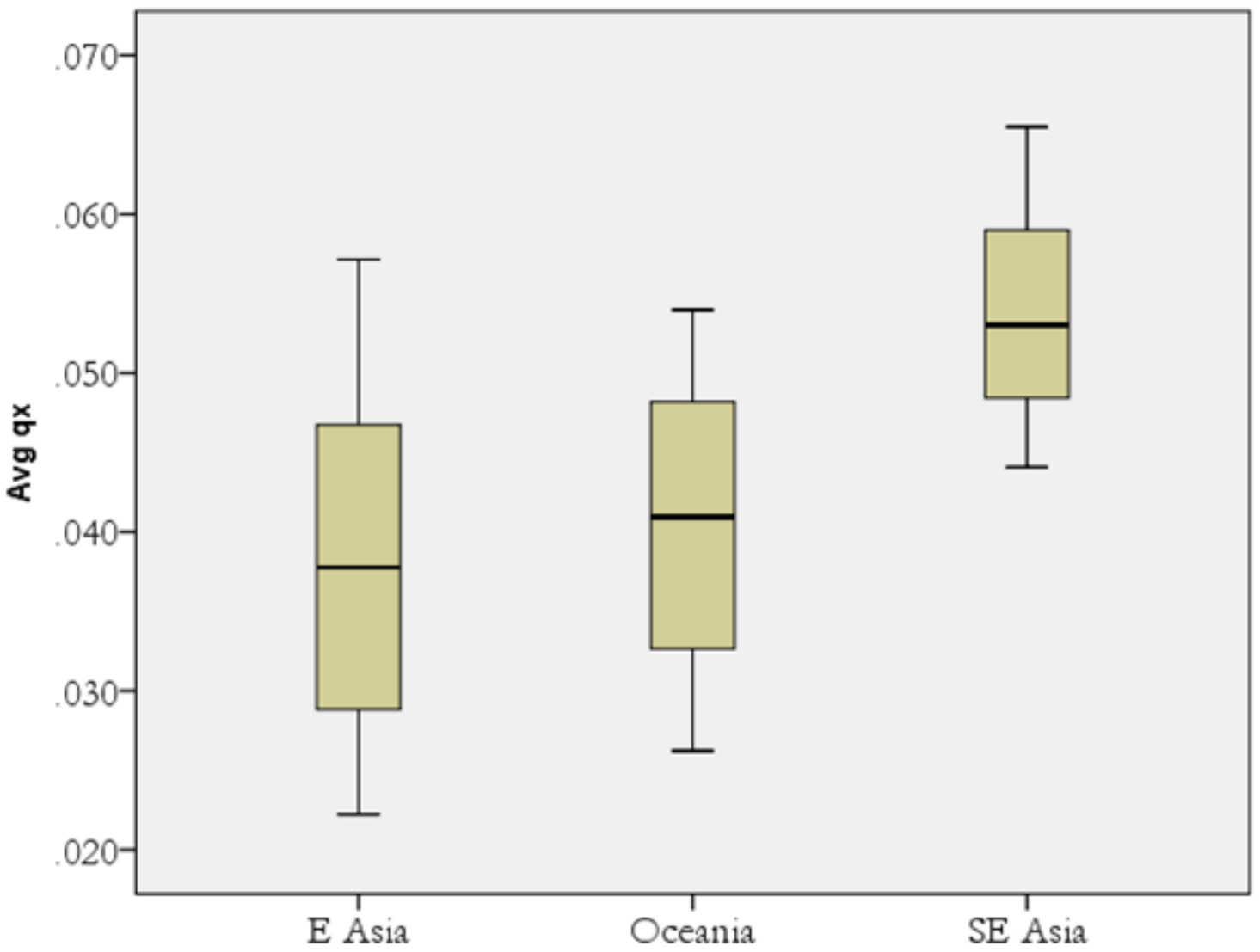
Mortality by region, Female, Age *60*
APAG (Females: 1950 - 2012)



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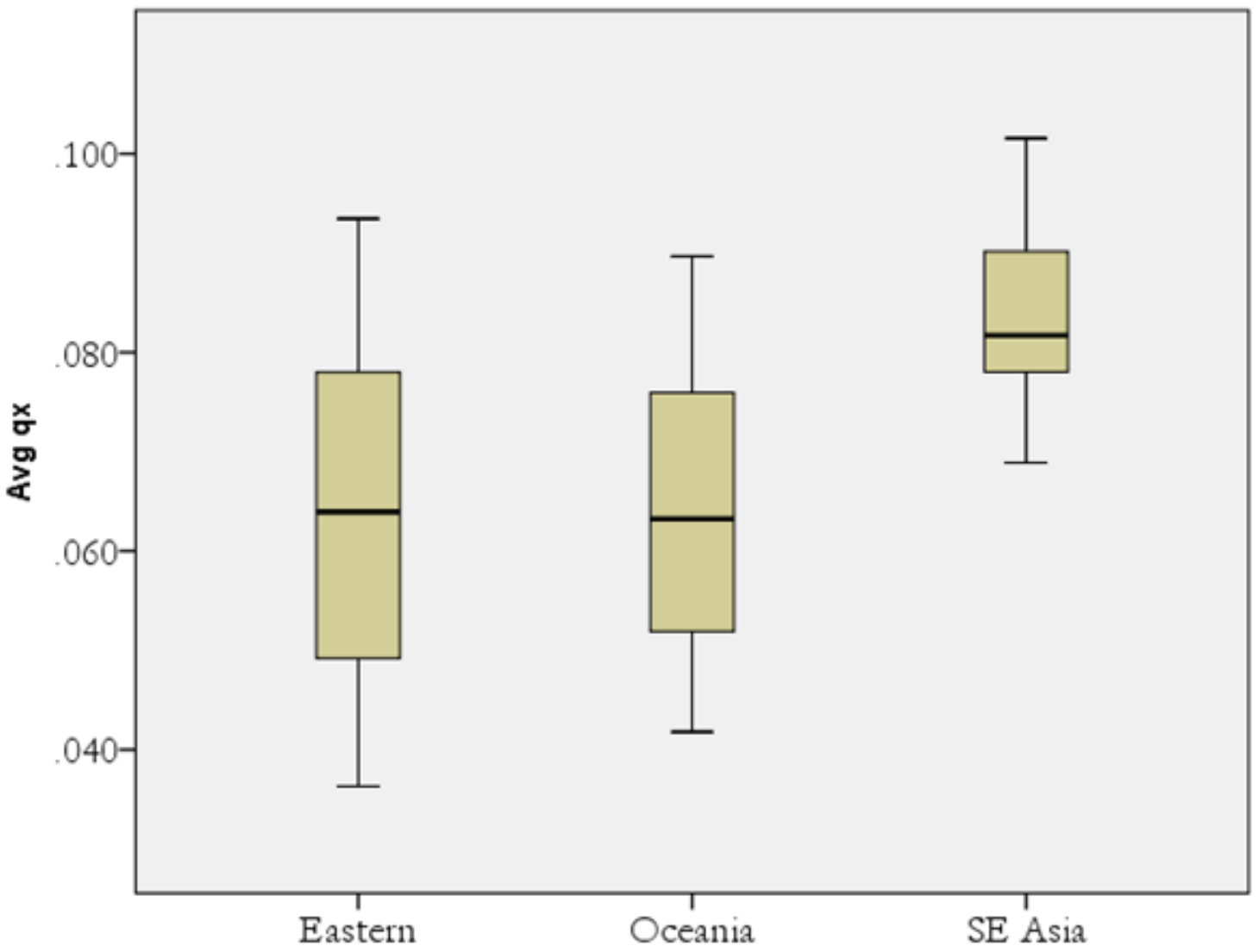
Mortality by region, Female, Age *65*
APAG (Females: 1950 - 2012)



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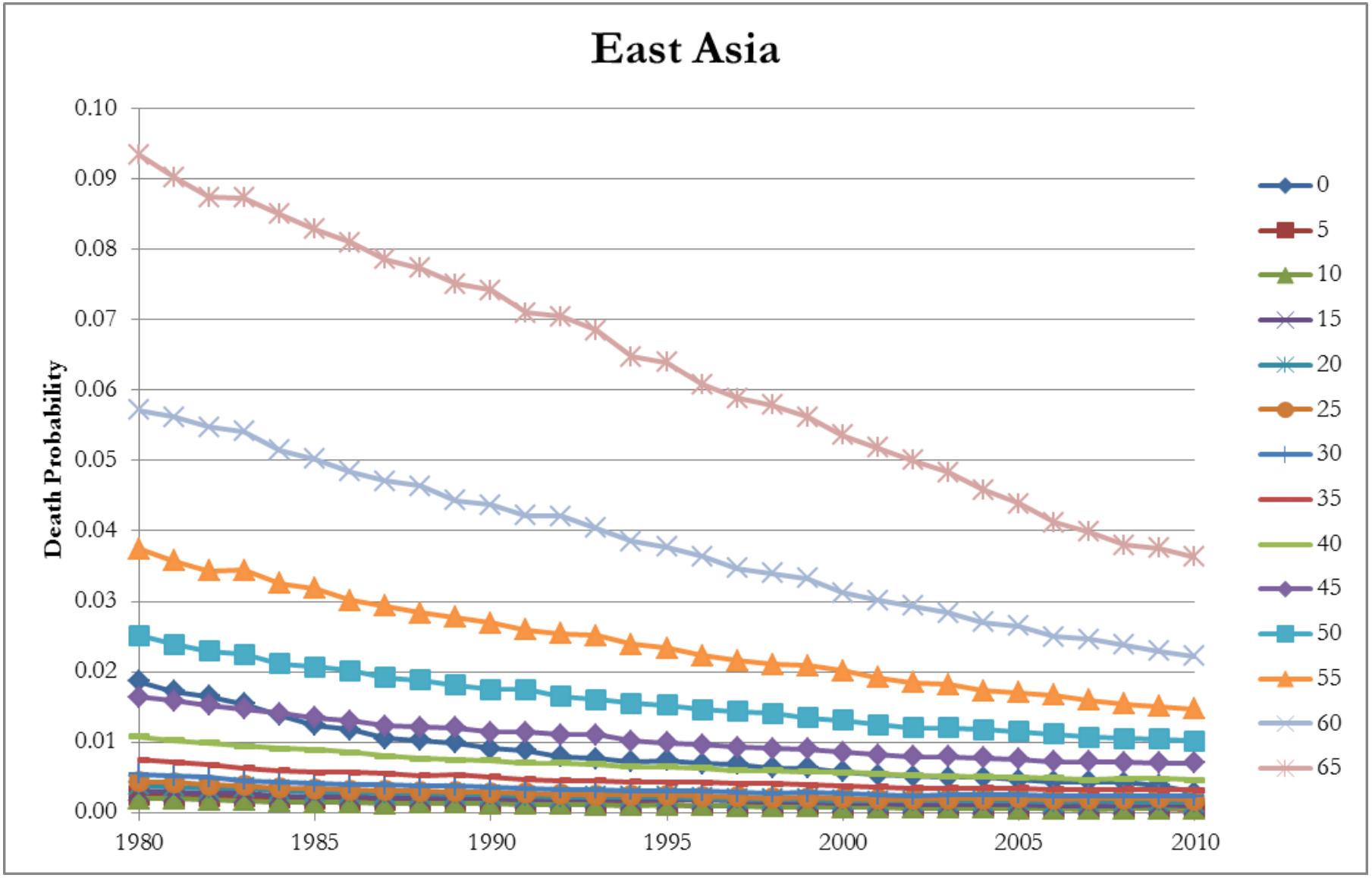
Mortality by Year, Age: *East Asia* APAG (Females: 1950 - 2012)



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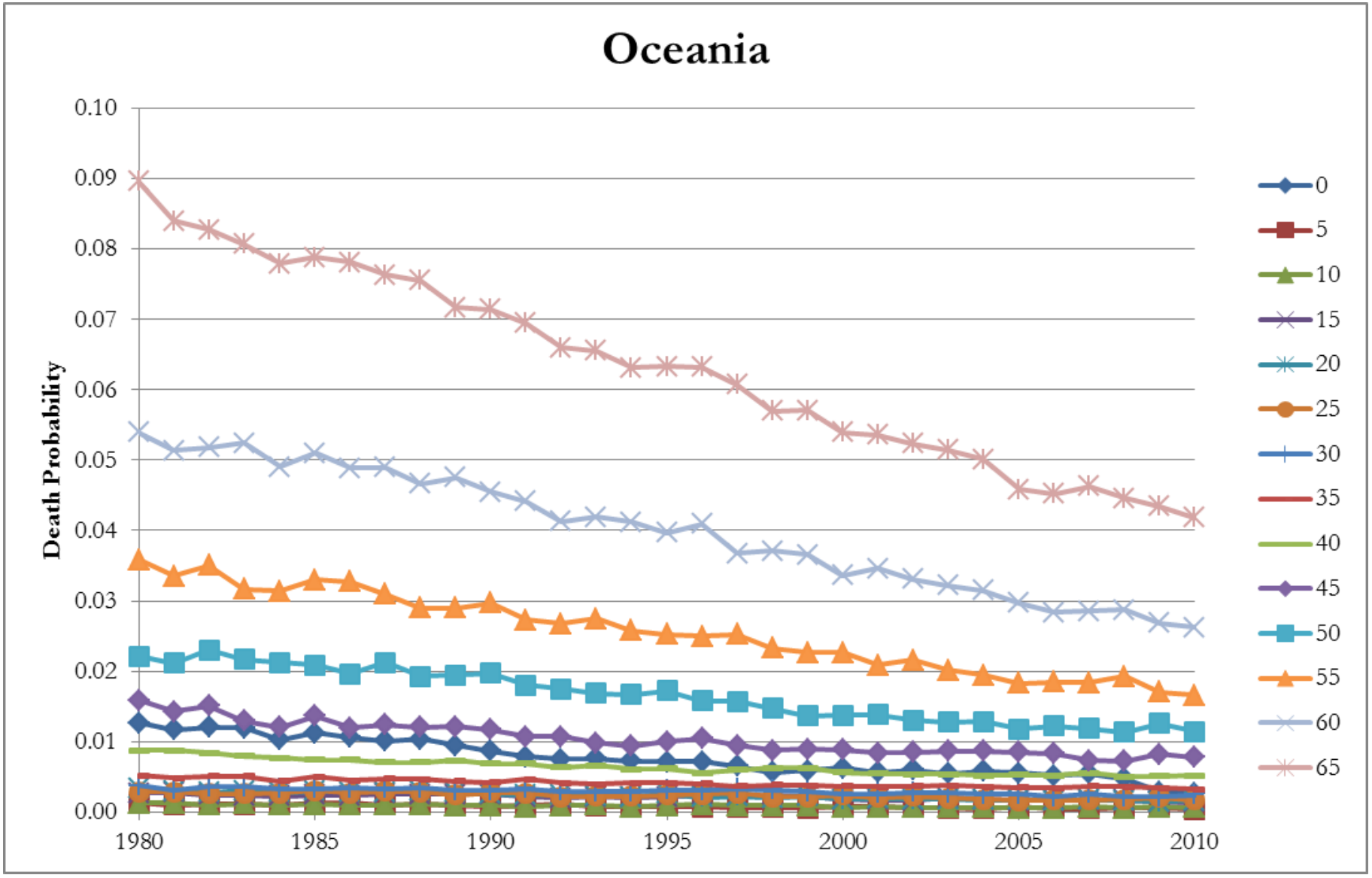
Mortality by Year, Age: *Oceania* APAG (Females: 1950 - 2012)



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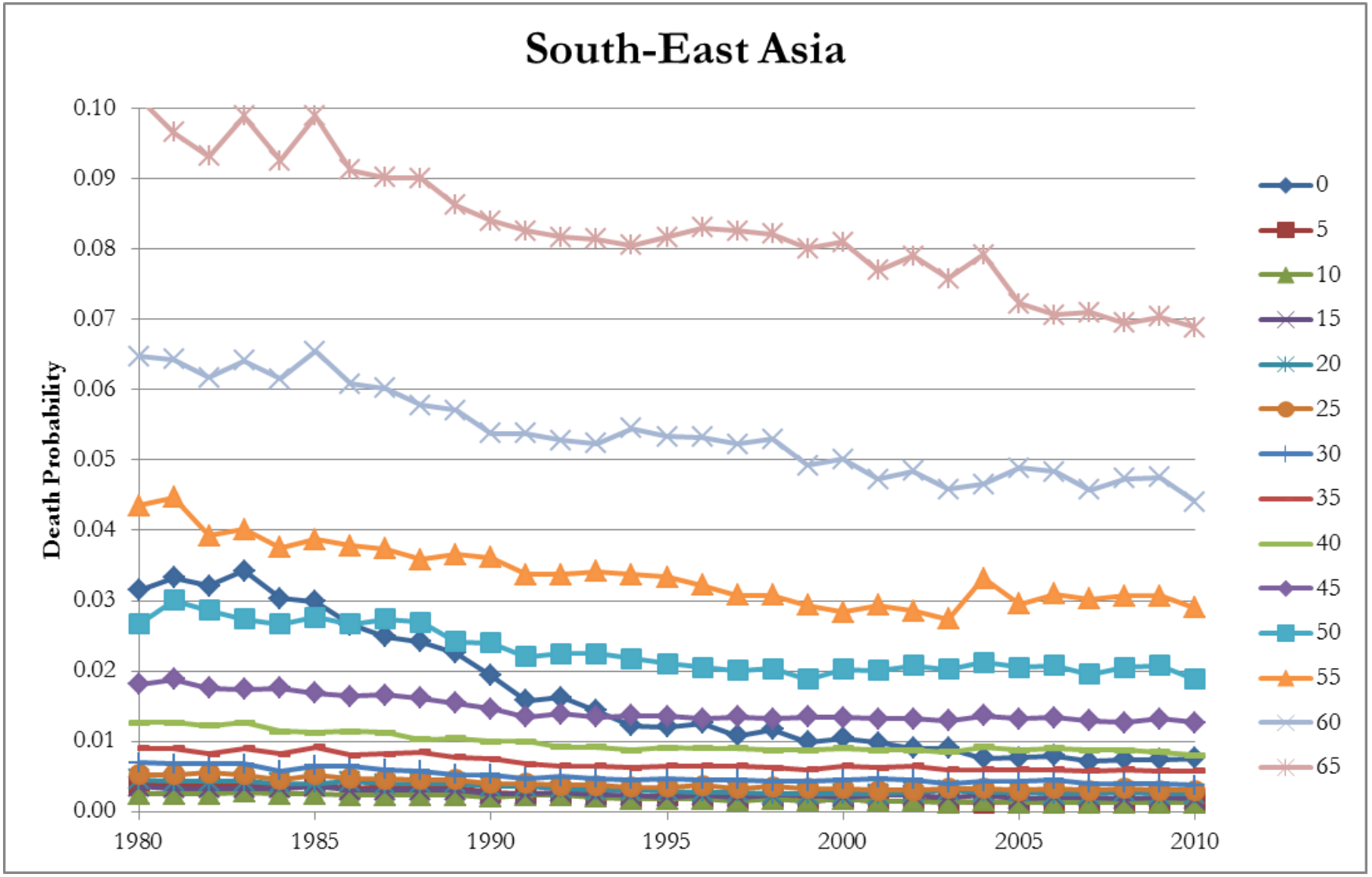
Mortality by Year, Age: *South-East Asia* APAG (Females: 1950 - 2012)



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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).

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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.

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4. Methodology

- **Li and Lee (2005)**

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

- $$K(t) = c + K(t-1) + \sigma_K e(t), \quad e(t) \sim \mathrm{N}(0,1)$$

- $$k(t,i) = r_{0,i} + r_{1,i}k(t-1,i) + \sigma_{k,i}e_i(t), \quad e_i(t) \sim \mathrm{N}(0,1)$$

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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.

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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.

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5. Why does Longevity Risk Sharing make sense?

- We may think of longevity risk as:

Total Risk = Common Risk + 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**.

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6. Results

Li and Lee (2005):

- **East Asia:**
  - **Hong-Kong, Japan, Korea & Taiwan.**
- Oceania:
  - Australia & New Zealand.
- South-East Asia:
  - Singapore & Philippines.

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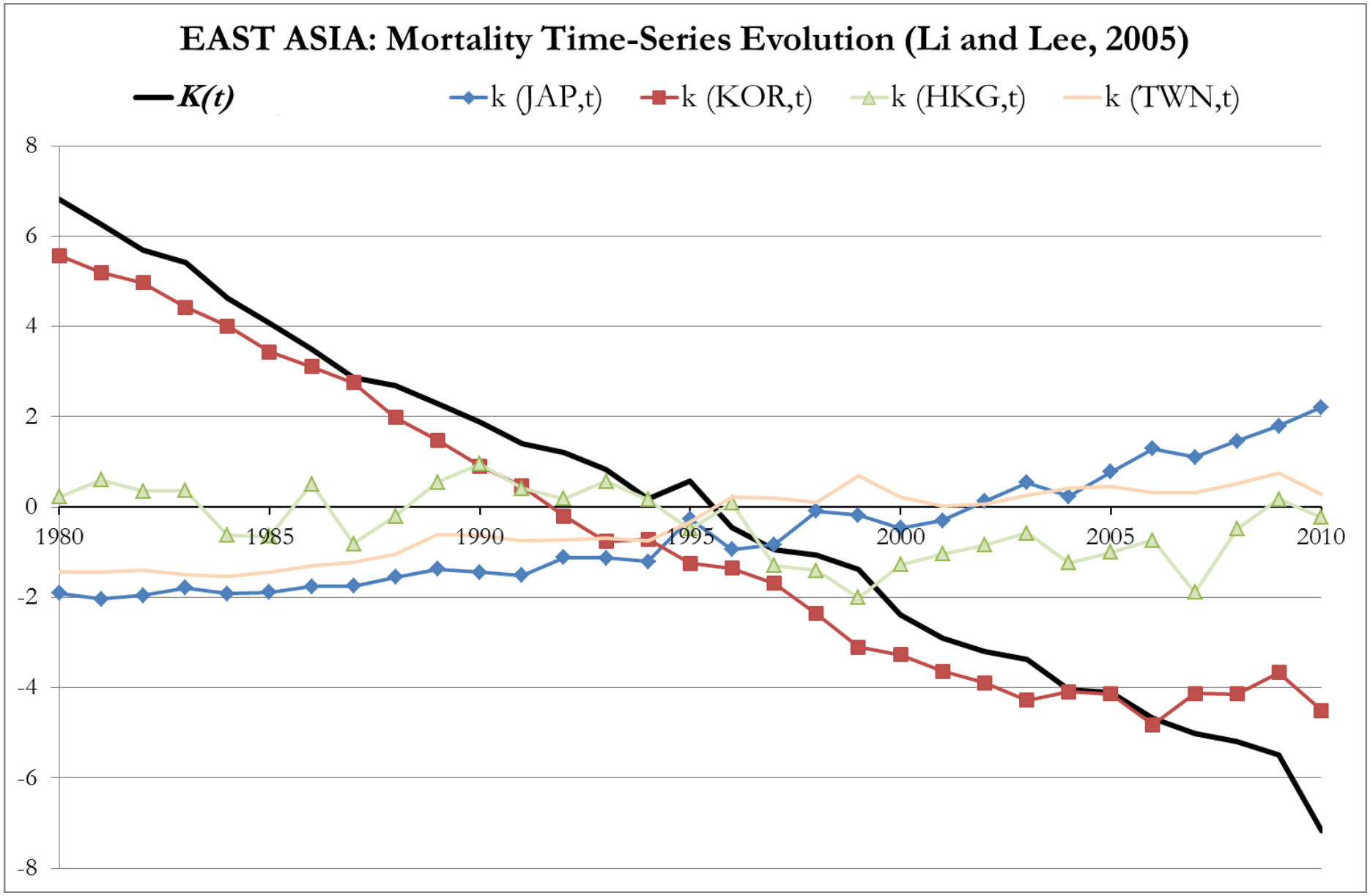
6. Results



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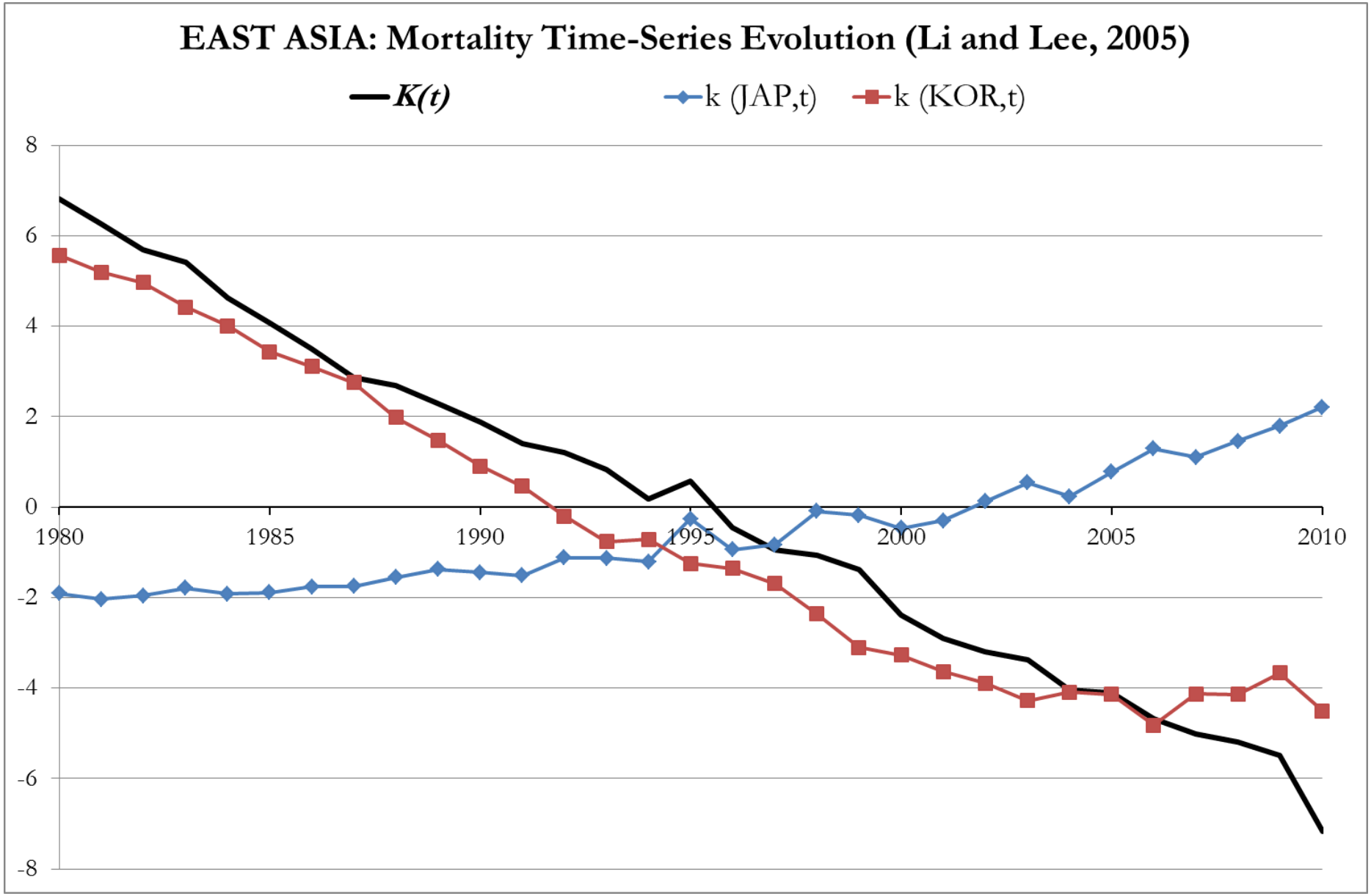
6. Results



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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%

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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: 10^{th} percentile of K(t)
  - Positive Deviation: 90^{th} percentile of K(t)

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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

K(t) Index	Instrument	JAP (long)	KOR (short)
Up	Pensions:	More at (t+1)	Less at (t+1)
	Forward:	Gain	Loss
Down	Pensions:	Less at (t+1)	More at (t+1)
	Forward:	Loss	Gain

7. Example: Why does longevity risk transfer make sense?

Example: 20-year Temporary Life Annuity-Due

	Japan			Korea		
Details	**Base**	**Negative**	**Positive**	**Base**	**Negative**	**Positive**
APV (with Total Risk)	$16.64	$16.50	$16.71	$16.34	$16.55	$16.10
APV (with Common Risk only)	$17.02	$17.12	$16.92	$15.55	$15.69	$15.42
APV of Total Risk		$0.14	$0.07		$0.21	$0.25
APV of Common Risk		$0.09	$0.10		$0.13	$0.14
APV of Country Risk		$0.23	$0.17		$0.08	$0.11
% of Common to Total Risk		-68%	-134%		63%	56%
% of Country to Total Risk		168%	234%		37%	44%

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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".

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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.**

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Feedback welcome:

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