

A Study on Risk Classification of Life Insurance Policies in Taiwan

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Outline

- **Motivation**
- **Exploratory Data Analysis (EDA)**
 - Analysis of Experience Mortality Rates and Risk factors
 - Mortality Improvement Rates
- **Policy Classification: Life Insurance Annuity**
 - PCA
 - Kmeans
 - Hierarchical Clustering-Wards
 - Self-defined Classification Conditions
- **Conclusion**

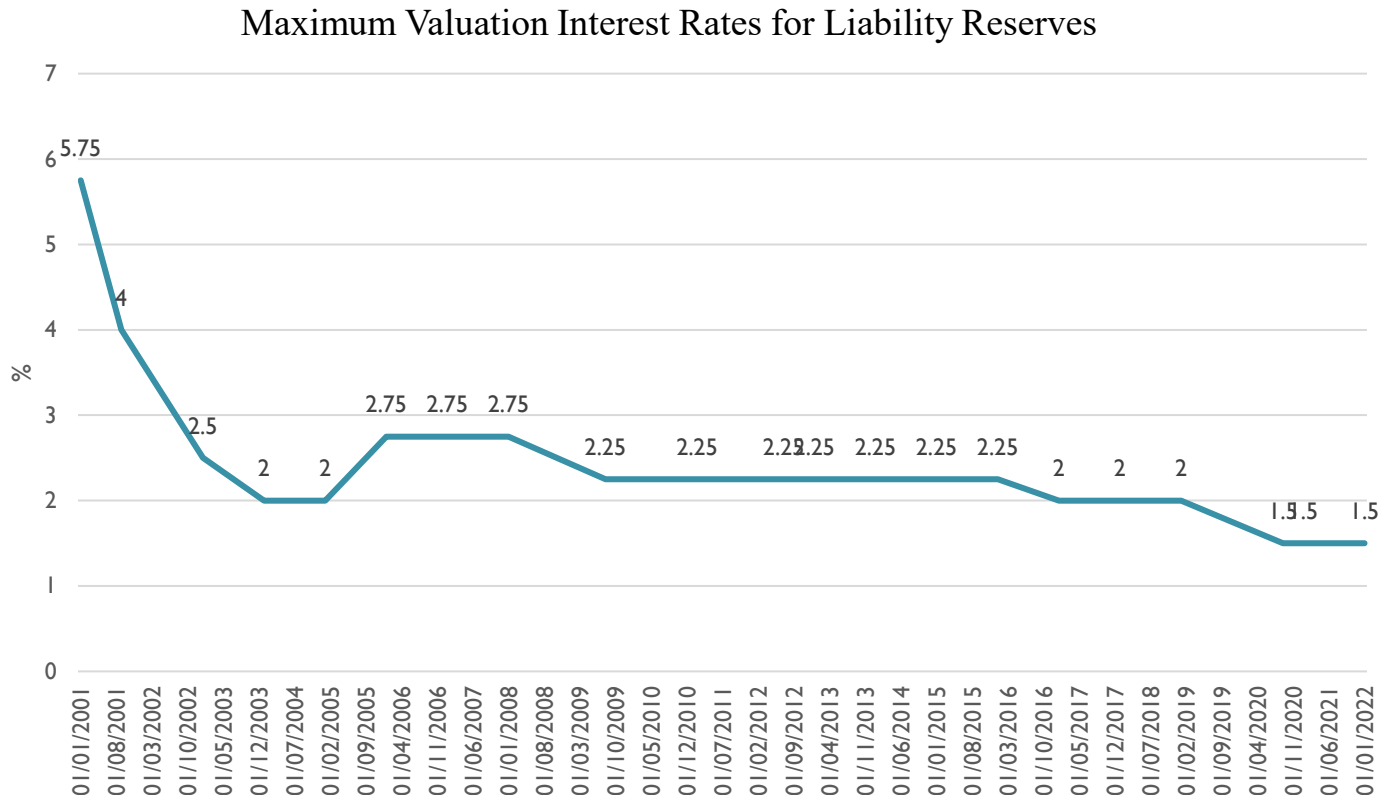
Motivation

- Mortality keeps improving in Taiwan
 - The life expectancies are **77.67** and **84.25** for Taiwan's men and women (source: the 2021 Abridged life table from Ministry of the Interior in Taiwan)
 - 1995-2020 the annual increments of the life expectancies are around **0.25** and **0.28** years for men and women of Taiwan Population (source: National Development Council)
 - The annual increment of life expectancy for Taiwan's life insurance is **0.37** years annually (source: 2012 and 2021 Taiwan Standard Ordinary Tables)
- Low-fertility rates
 - The total fertility rate (TFR) of Taiwan is **0.89 for 2021 year** (source: National Development Council)

Motivation

- Low-interest rates

➤ Maximum Valuation Interest Rates for Liability Reserves form 5.75% in 2001 year decline to 1.5% in 2022 year. (Note: Taiwan life insurance industry was opened to sell investment-type insurance products from 2001)



➔ Population ageing and the impact of **low-interest rates** have led insurance companies to problems related to increased longevity and mortality risk.

Motivation

- In Taiwan, in addition to the protection function, the insurance policies also serve as major tools for investments or savings by most people
 - The option of **principal repayment** is very popular and is the major attribute of many Taiwan life insurance products.
 - A **term life policy** will behave like an **endowment policy** if the percentage of principal repayment is high
 - A **whole life policy** will behave like **an annuity policy**
- Source: Yue J.C. and Huang H.C. (2011) A Study of Incidence Experience for Taiwan Life Insurance, The Geneva Papers on Risk and Insurance - Issues and Practice volume 36, pages 718–733
- High premium, low commission, and no tax benefits make annuity products are not popular
- On the basis of the life insurance products, we should **create different life tables to reflect true market situation** by the difference between the survival responsibility and longevity risk.

Motivation

- Taiwan expects to adopt International Financial Reporting Standards 17 (IFRS 17) in 2026.

Insurance companies will face a **huge capital increase pressure**, also need **appropriate policy classification to facilitate the application of different liability measurement models and marketing strategies.**

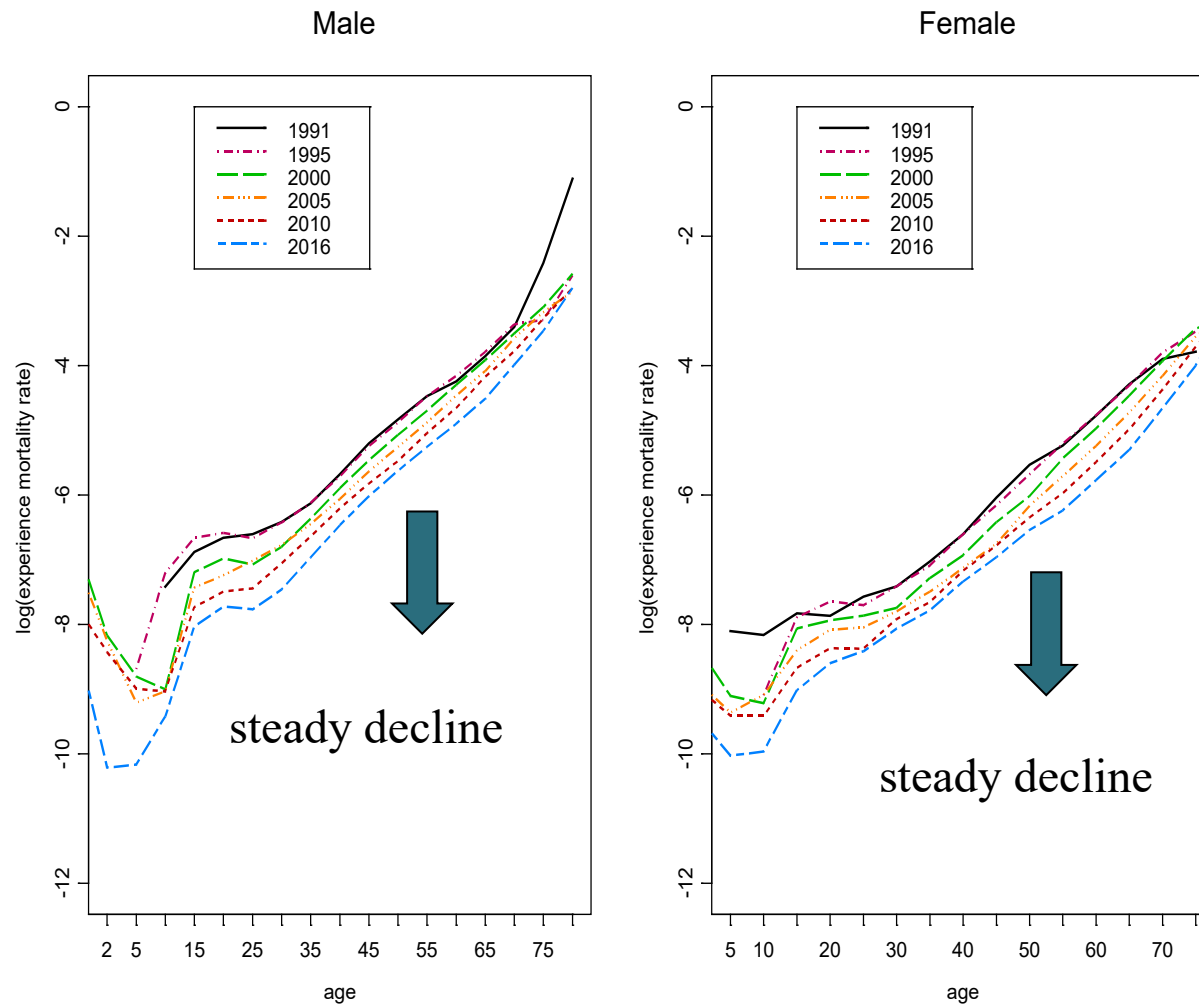
- **Small Population**

- It is difficult to estimate the empirical mortality rates and to fully quantify the **potential risk for small populations**, i.e., small insurance companies or insurance products with few exposures.

==> **Choosing a reference population** is a popular choice to stabilize the experience mortality rates of small populations

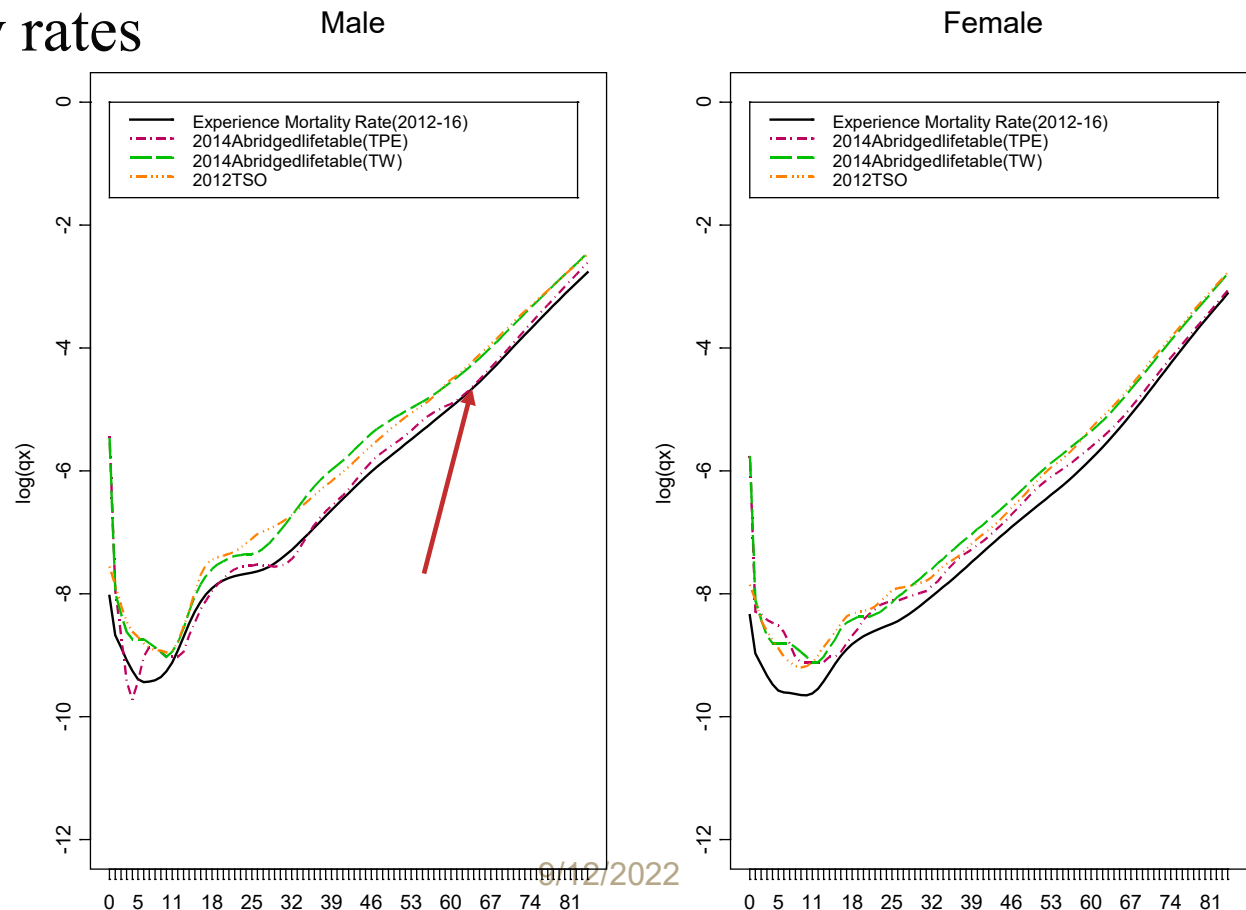
Analysis of Experience Mortality Rates

- Mortality Rates **Continue to Decline** at all age groups



Analysis of Experience Mortality Rates

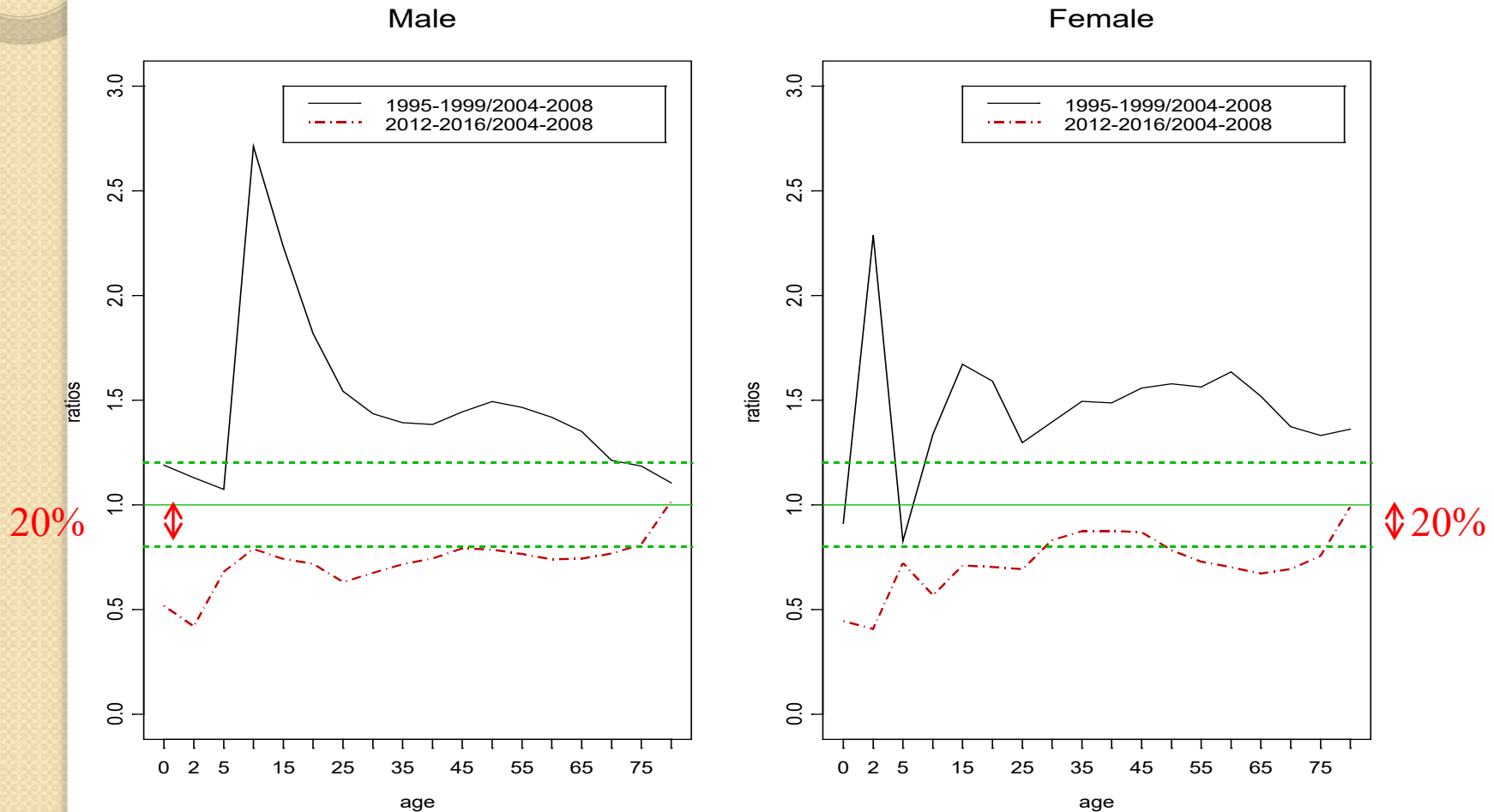
- Insurer's Experience Mortality Rates approach to **Taipei City's**, with the **highest life expectancy city in Taiwan**
- 2012 Taiwan Standard Ordinary Experience Mortality Table (TSO) is **significantly higher than** 2012-16 average experience mortality rates



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Analysis of Experience Mortality Rates

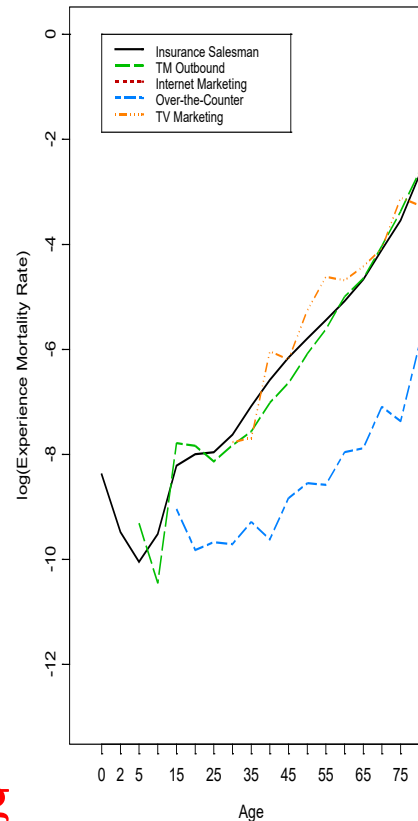
- At least 20% mortality improvement rate for 10 years
- Younger and age 50-75 people have obviously improvement



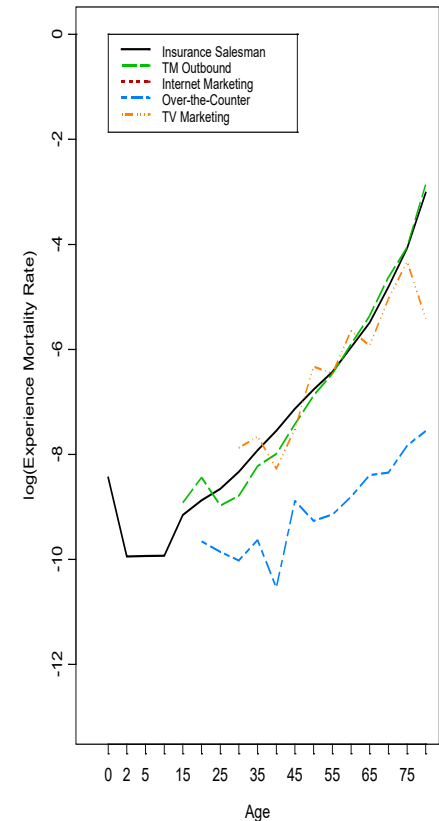
Risk factors

- Insurance products purchased by consumers may also be **affected by different sales channels and sales skills of salesman.**
- The **over-the-counter selling** has smallest mortality rate than the other sale methods.
 - The policies sold by **banks or TM(Telemarketing) outbound** are usually simple, principal repayment and short-term of the insurance period.
 - It seems shows there are no much of a difference of **sales skill among banks' financial consultants, TM outbound, salesman** at the insurance company.

Ways of Selling: Male(2014-17)



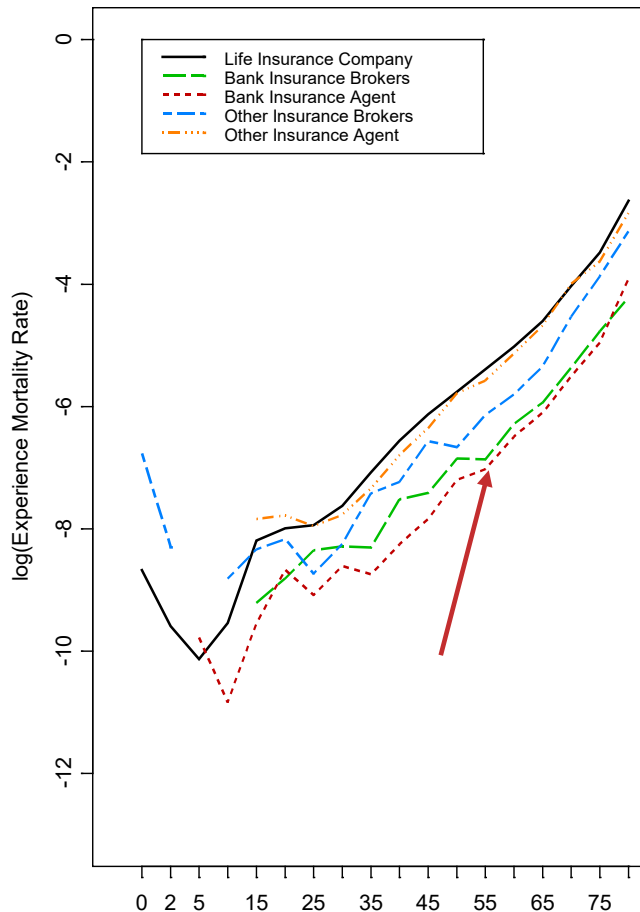
Ways of Selling: Female(2014-17)



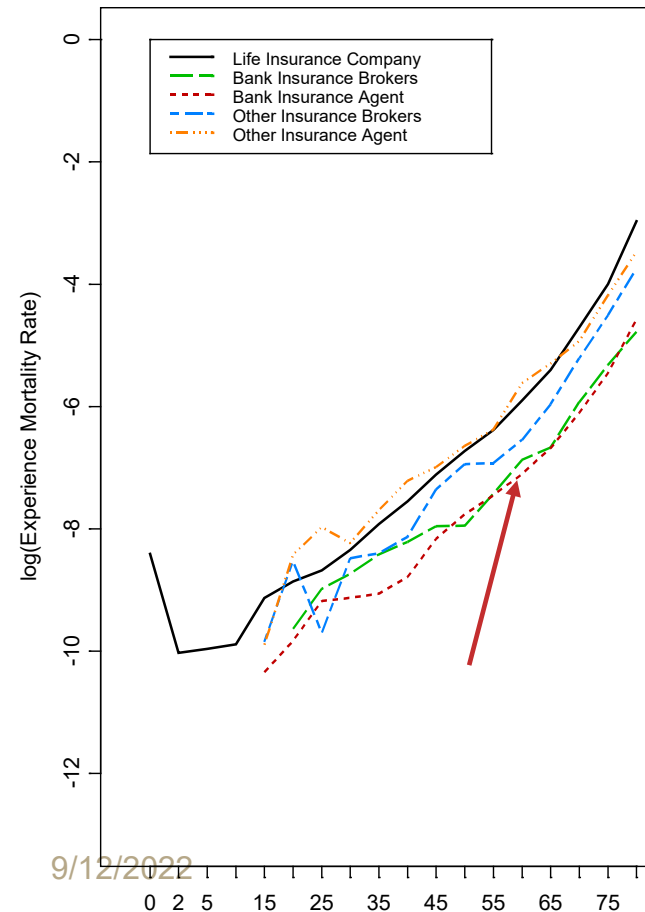
Risk factors

- The Mortality Rates of **Bank channel** of selling policies are smaller than insurance company's.
- Does that mean the **quality of bank customers** is better or it related to **sell products**? It worthy more in-depth research in the future.

Channel of Selling: Male(2014-17)

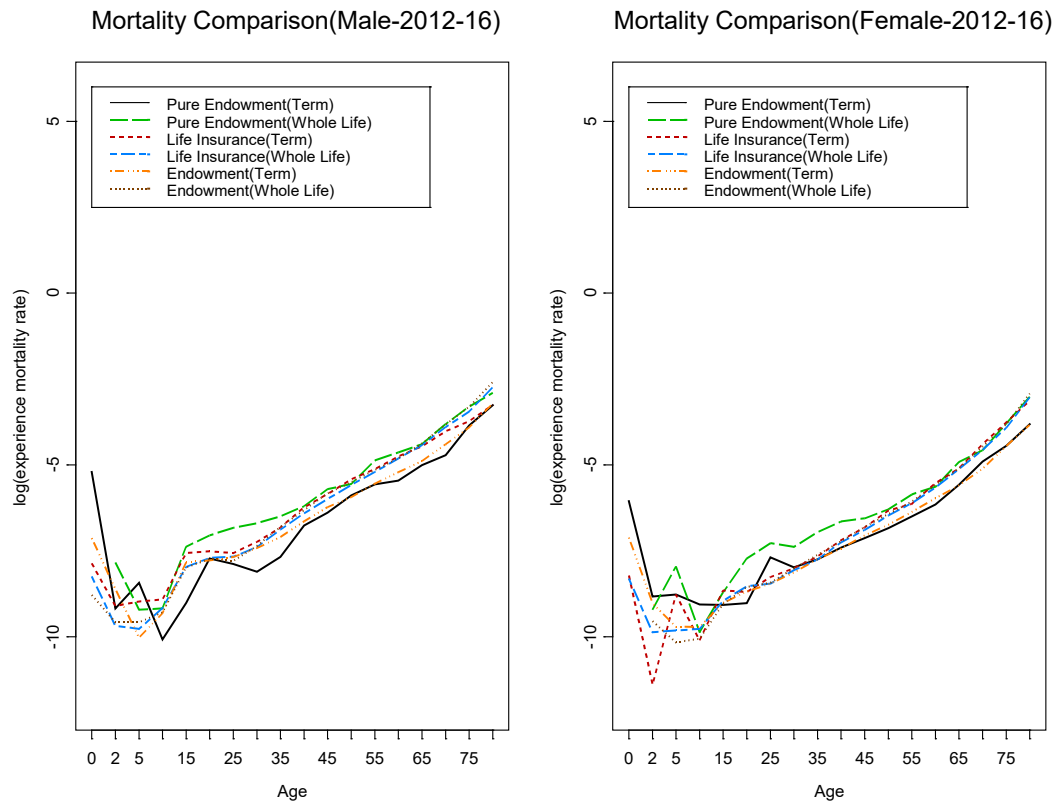


Channel of Selling: Female(2014-17)



Risk factors

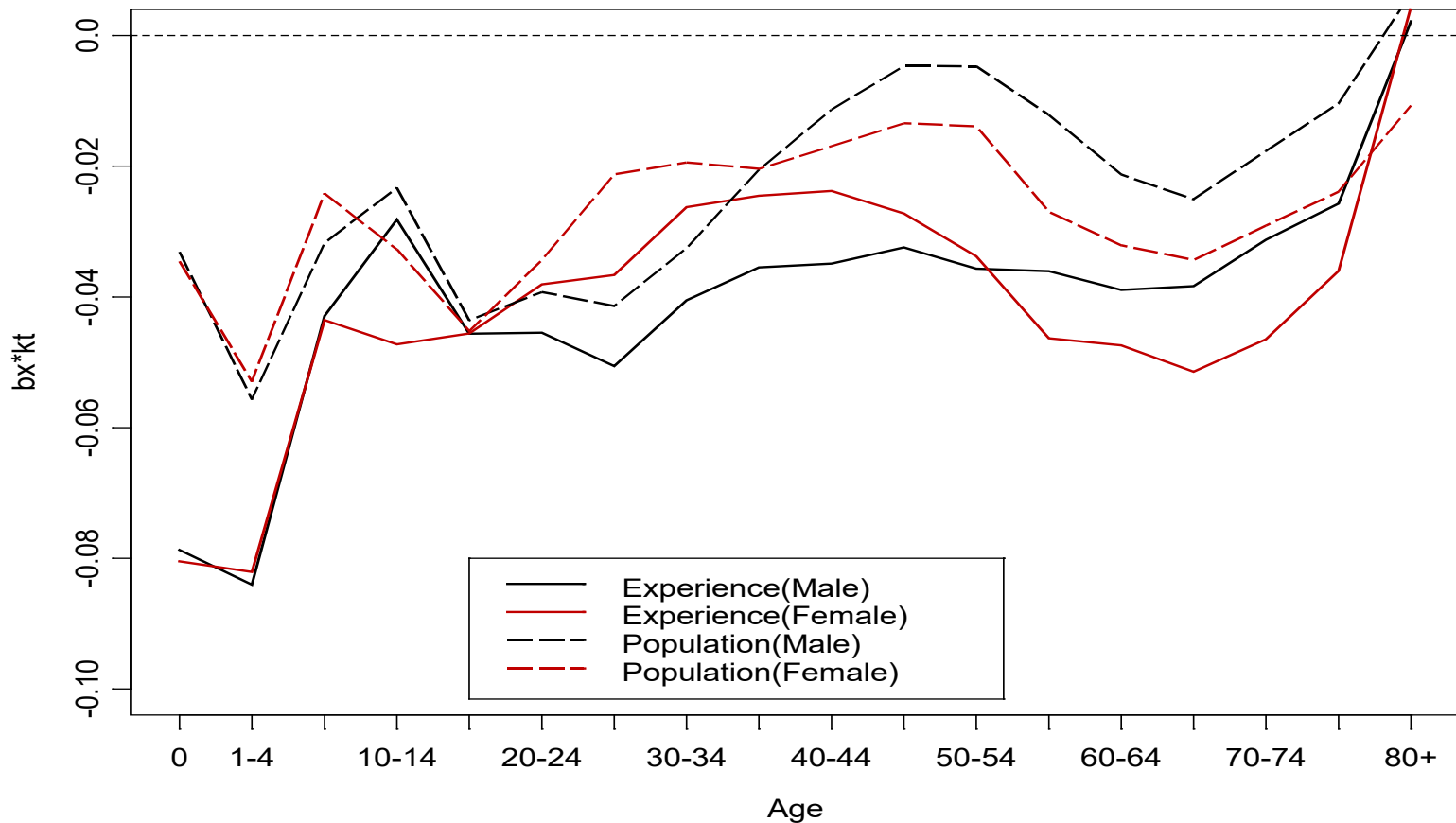
- **Principal-repayment** and **policy period** are significantly affect mortality rates
- Principal-repayment means **maturity or refund benefit payment** in life insurance, annuity and **cash surrender value** in increasing whole life, which many people as it savings or investment tool in Taiwan.



Mortality Improvement Rates

- Mortality improvement rates of **Taiwan life insurance industry** is **lower than** Taiwan population (LC Model, 2000-16)

Mortality Imporment Rate in Taiwan(2000-2016)



Policy Classification

- Mortality indexes:

- Crude Death Rate(**CDR**)

- Standardized Mortality Ratio (**SMR**): the reference population is all insurance products

- Data: 16 insurance products (2011-16 years)

Source: Taiwan Insurance Institute

- Data classification methods: Principal Component Analysis(**PCA**), **K-means** Clustering, and **Hierarchical Clustering** and **Self-defined Classification Conditions**

Policy Classification

Pure Endowment(Term)

Pure Endowment(Whole Life)

Life Insurance(Term)

Life Insurance(Whole Life)

Endowment(Term)

Endowment(Whole Life)

Interest-Sensitive Pure Endowment

Interest-Sensitive Life Insurance(Term)

Interest-Sensitive Life Insurance(Whole Life)

Interest-Sensitive Endowment(Term)

Interest-Sensitive Endowment(Whole Life)

Investment Link Product Pure Endowment

Investment Link Product Life Insurance(Term)

Investment Link Product Life Insurance(Whole Life)

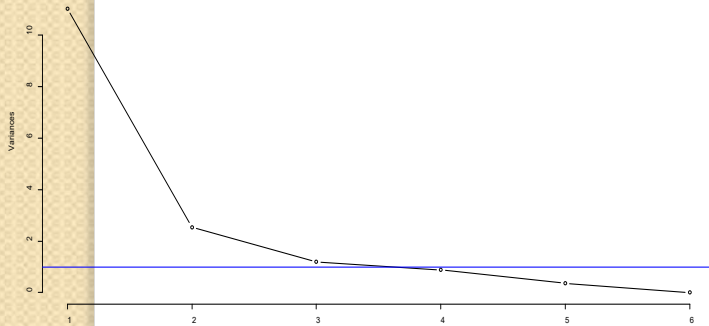
Investment Link Product Endowment(Term)

Investment Link Product Endowment(Whole Life)

Principal Component Analysis (PCA)

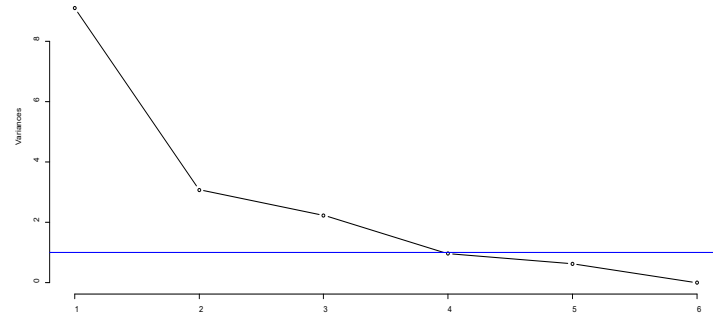
- These **Scree plots** show that **the first three or four** components explain the majority of the variance in our data.
- Ex. CDR(Male) The **cumulative proportion of explained variance** corresponding to the three principal components are 69%, 85%, **92%**

Scree Plot (Male)-CDR



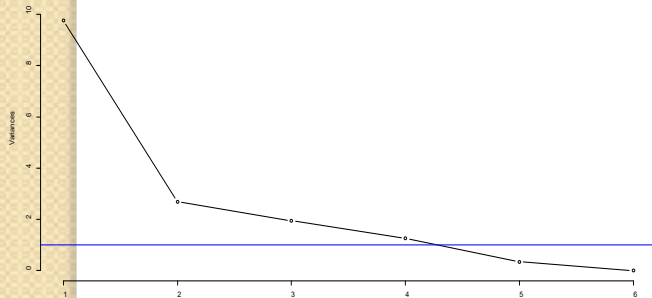
CDR

Scree Plot (Male)-SMR

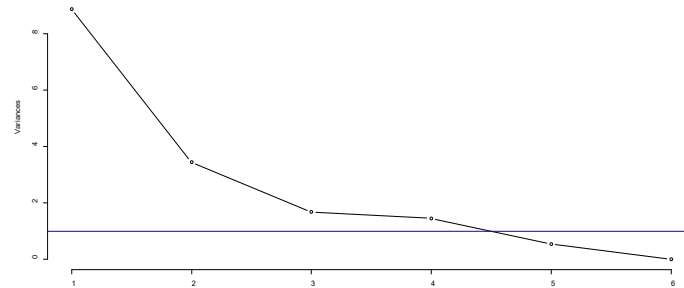


SMR

Scree Plot (Female)-CDR



Scree Plot (Female)-SMR



Principal Component Analysis (PCA)

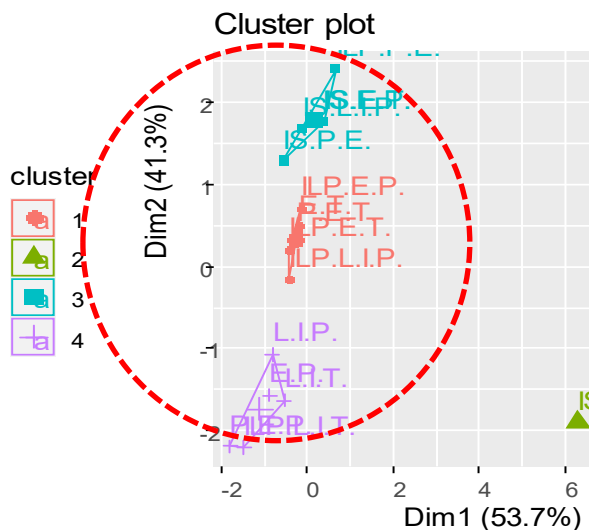
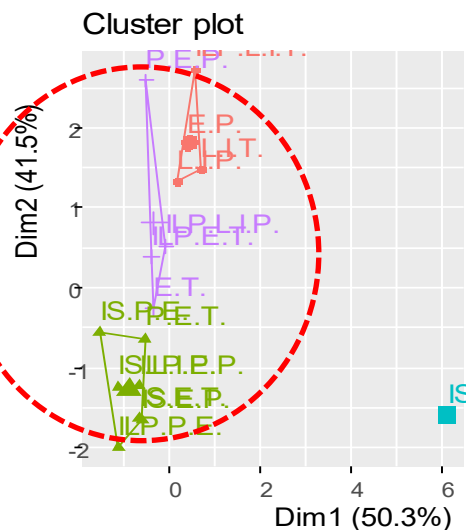
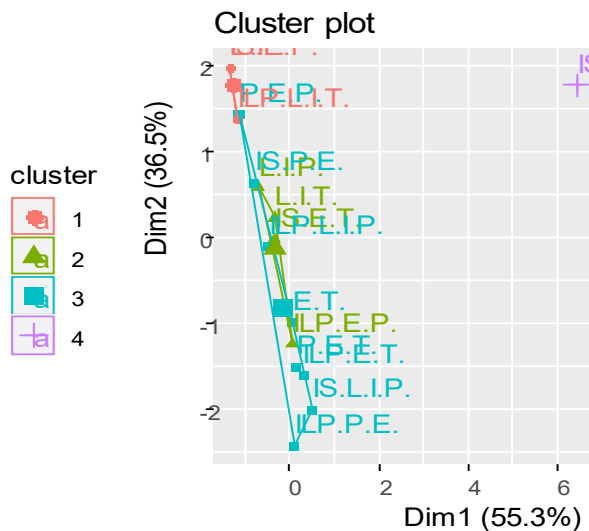
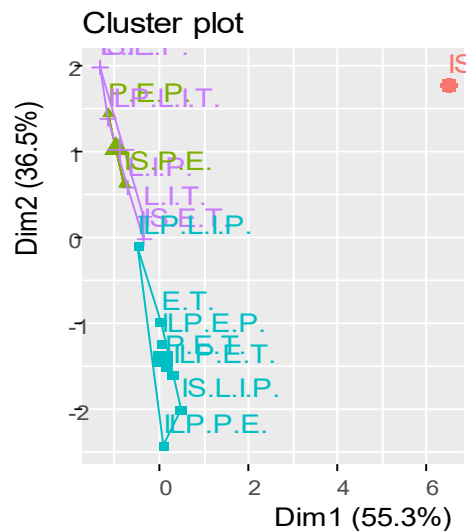
● By observing the coefficients (eigenvectors) of the original variables in the linear combination in each component, we can **choice the positive weighted** of the relationship between the principal components and the original variables

➤ Ex SMR(Male): **First component** seems to be related “**Savings**”; **Second component** seems to be related “**Investment**”; **Third component** seems to be related “**Protection**”

	First	Second	Third
Pure Endowment(Term)	-0.195006634	0.419124131	0.08713258
Pure Endowment(Whole Life)	0.30011353	-0.184729647	-0.10117208
Life Insurance(Term)	-0.288571704	-0.23870062	0.12491127
Life Insurance(Whole Life)	-0.167696046	-0.376000664	-0.23759419
Endowment(Term)	-0.323778922	-0.006925607	-0.07845679
Endowment(Whole Life)	-0.256730516	-0.332458637	-0.09161275
Interest-Sensitive Pure Endowment	0.326294266	-0.06746131	-0.00299632
Interest-Sensitive Life Insurance(Term)	-0.237078211	-0.208917785	0.39524437
Interest-Sensitive Life Insurance(Whole Life)	0.279834391	-0.216401761	0.10070668
Interest-Sensitive Endowment(Term)	-0.326592708	0.05848461	0.05743391
Interest-Sensitive Endowment(Whole Life)	-0.163762398	-0.42303711	0.24117951
Investment Link Product Pure Endowment	-0.046277005	0.2470674	0.59349699
Investment Link Product Life Insurance(Term)	0.164556233	-0.17986622	0.42157407
Investment Link Product Life Insurance(Whole Life)	-0.261179892	0.064733867	-0.36709724
Investment Link Product Endowment(Term)	0.273677041	0.086276987	-0.03558687
Investment Link Product Endowment(Whole Life)	-0.207289013	0.314391697	0.04176866

K-means

- Top Left(CDR-Male), Top right(CDR-Female), bottom left(SMR-Male), bottom right(SMR-Female)



- SMR-Kmeans can separate significantly 16 insurance products into **three** groups than CDR-Kmeans

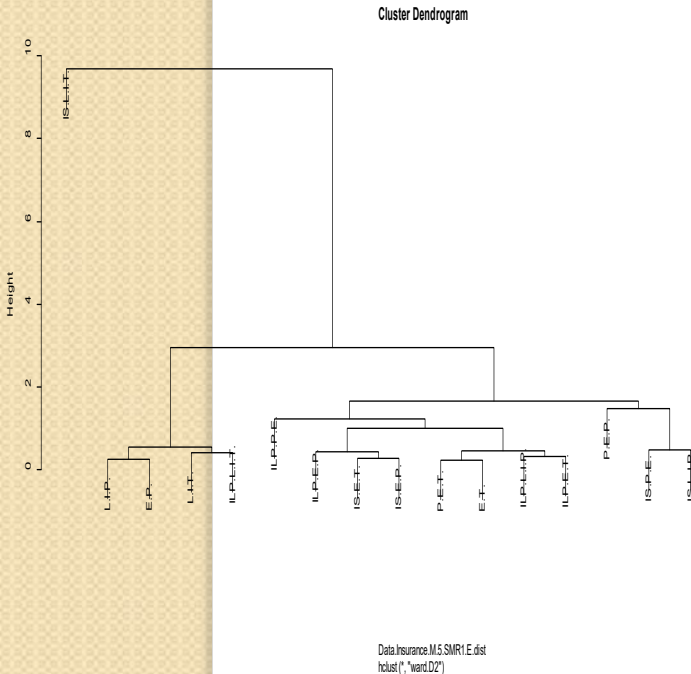
Kmeans

- Ex SMR(Male): “2” seems to be related “Savings”; “4” seems to be related “Investment”; “1” seems to be related “Protection”

	k=2	k=3	k=4
Pure Endowment(Term)	2	3	2
Pure Endowment(Whole Life)	2	2	4
Life Insurance(Term)	2	2	1
Life Insurance(Whole Life)	2	2	1
Endowment(Term)	2	3	4
Endowment(Whole Life)	2	2	1
Interest-Sensitive Pure Endowment	2	3	2
Interest-Sensitive Life Insurance(Term)----Outliers	1	1	3
Interest-Sensitive Life Insurance(Whole Life)	2	3	2
Interest-Sensitive Endowment(Term)	2	3	2
Interest-Sensitive Endowment(Whole Life)	2	3	2
Investment Link Product Pure Endowment	2	3	2
Investment Link Product Life Insurance(Term)	2	2	1
Investment Link Product Life Insurance(Whole Life)	2	2	4
Investment Link Product Endowment(Term)	2	3	4
Investment Link Product Endowment(Whole Life)	2	3	2

Hierarchical Clustering

- Ex SMR(Male): “3” seems to be related “Savings”; “1” seems to be related “Investment”; “2” seems to be related “Protection”



	Ward
Pure Endowment(Term)	1
Pure Endowment(Whole Life)	3
Life Insurance(Term)	2
Life Insurance(Whole Life)	2
Endowment(Term)	1
Endowment(Whole Life)	2
Interest-Sensitive Pure Endowment	3
Interest-Sensitive Life Insurance(Term)----Outliers	Outliers
Interest-Sensitive Life Insurance(Whole Life)	3
Interest-Sensitive Endowment(Term)	1
Interest-Sensitive Endowment(Whole Life)	1
Investment Link Product Pure Endowment	1
Investment Link Product Life Insurance(Term)	2
Investment Link Product Life Insurance(Whole Life)	1
Investment Link Product Endowment(Term)	1
Investment Link Product Endowment(Whole Life)	1

Comparison(CDR)

- ● Protection(Group I), ▲ Investment(Group II), ■ Savings(Group III)
- **Yellow marks** mean that three methods put the insurance product to the same group

	Male			Female		
	PCA	K means	Hierarchical Clustering	PCA	K means	Hierarchical Clustering
Pure Endowment(Term)	▲	▲	▲	■	▲	▲
Pure Endowment(Whole Life)	■	●	■	■	▲	●
Life Insurance(Term)	●	●	●	●	●	●
Life Insurance(Whole Life)	■	●	●	■	●	●
Endowment(Term)	▲	▲	▲	●	▲	▲
Endowment(Whole Life)	■	●	●	■	■	■
Interest-Sensitive Pure Endowment	■	●	■	■	▲	●
Interest-Sensitive Life Insurance(Term)	●	—	—	●	—	—
Interest-Sensitive Life Insurance(Whole Life)	●	▲	▲	▲	▲	▲
Interest-Sensitive Endowment(Term)	▲	●	●	●	●	●
Interest-Sensitive Endowment(Whole Life)	■	●	●	●	■	■
Investment Link Product Pure Endowment	▲	▲	▲	—	▲	▲
Investment Link Product Life Insurance(Term)	■	●	●	■	■	■
Investment Link Product Life Insurance(Whole Life)	■	▲	▲	■	▲	●
Investment Link Product Endowment(Term)	■	▲	▲	●	▲	▲
Investment Link Product Endowment(Whole Life)	▲	▲	▲	—	●	●

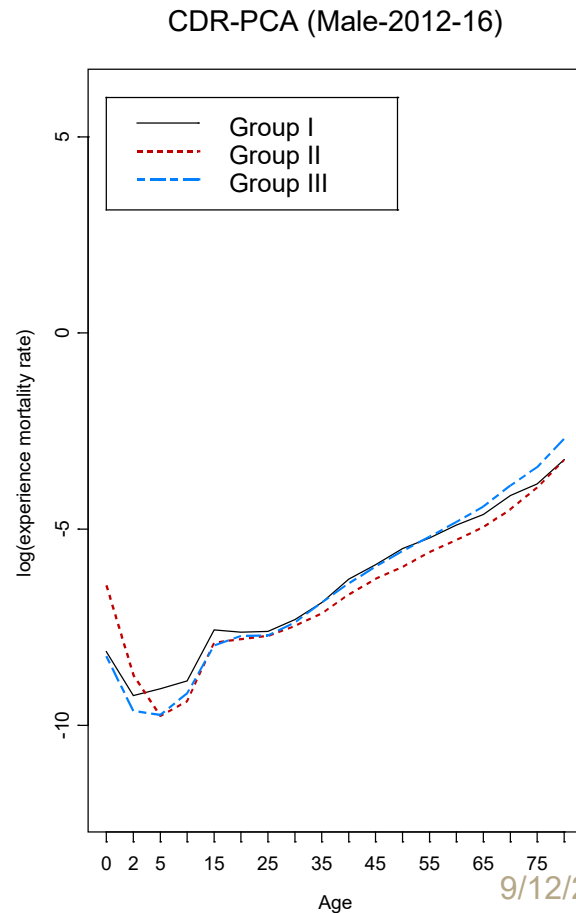
Comparison(SMR)

- Protection(Group I), ▲ Investment(Group II), ■ Savings(Group III)
- Yellow marks mean that three methods cluster the insurance product to the same group

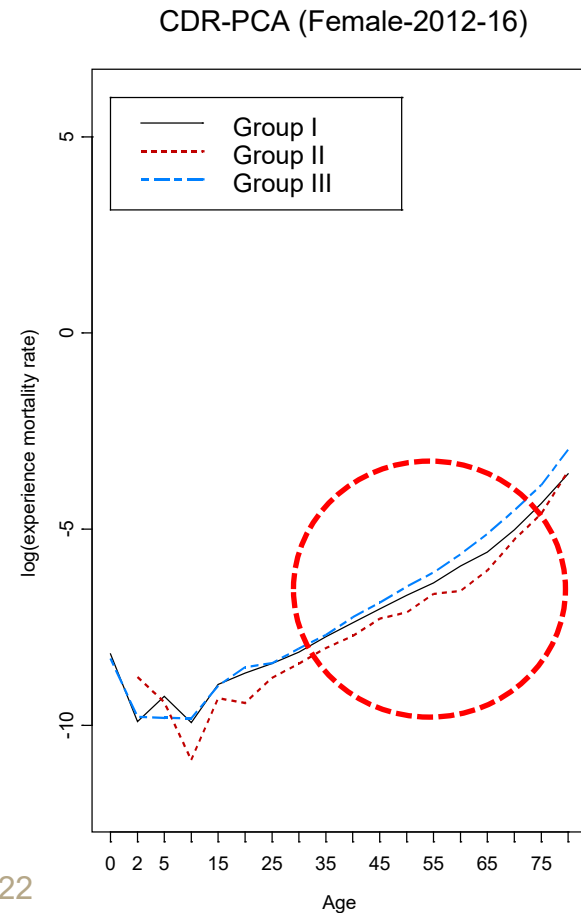
	Male			Female		
	PCA	K means	Hierarchical Clustering	PCA	K means	Hierarchical Clustering
Pure Endowment(Term)	▲	■	▲	▲	▲	▲
Pure Endowment(Whole Life)	■	▲	■	■	●	●
Life Insurance(Term)	●	●	●	—	●	●
Life Insurance(Whole Life)	—	●	●	—	●	●
Endowment(Term)	—	▲	▲	—	▲	▲
Endowment(Whole Life)	—	●	●	—	●	●
Interest-Sensitive Pure Endowment	■	■	■	■	■	■
Interest-Sensitive Life Insurance(Term)	●	—	—	●	—	—
Interest-Sensitive Life Insurance(Whole Life)	■	■	■	■	■	■
Interest-Sensitive Endowment(Term)	▲	■	▲	▲	■	■
Interest-Sensitive Endowment(Whole Life)	●	■	▲	●	■	■
Investment Link Product Pure Endowment	▲	■	▲	▲	■	■
Investment Link Product Life Insurance(Term)	●	●	●	▲	●	●
Investment Link Product Life Insurance(Whole Life)	▲	▲	▲	▲	▲	▲
Investment Link Product Endowment(Term)	■	▲	▲	●	▲	▲
Investment Link Product Endowment(Whole Life)	▲	■	▲	▲	▲	▲

Experience Mortality Rates(CDR-PCA)

- **Female** is more clearly to be clustered into three groups than male
- Male: Group I(Protection)=Group III(Savings)>**Group II(Investment)**
- Female: Group III(Savings)>Group I (Protection)>**Group II(Investment)**



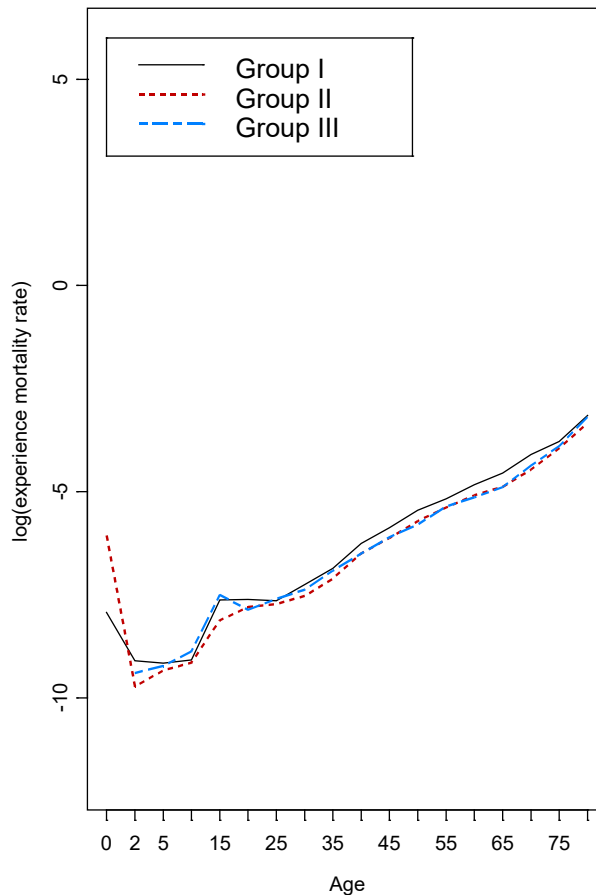
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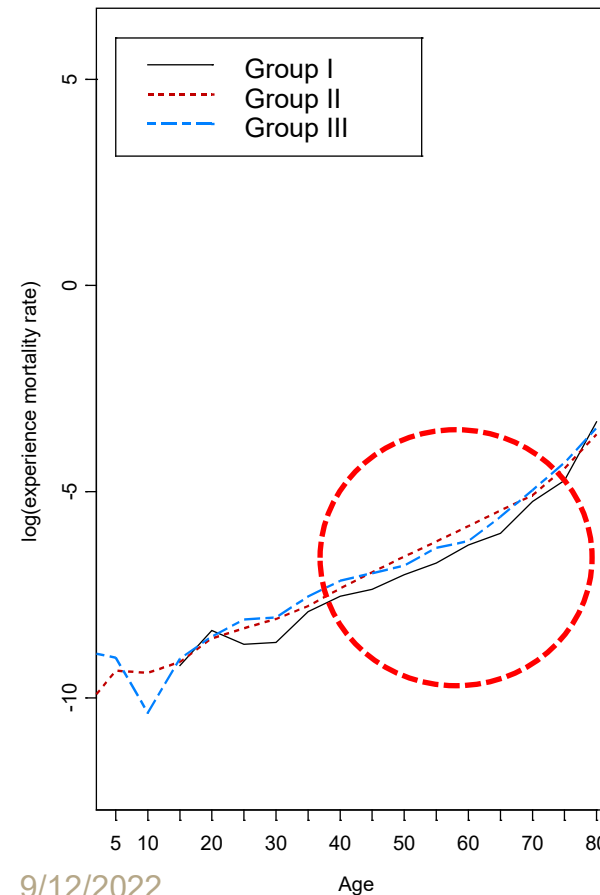
Experience Mortality Rates(SMR-PCA)

- Male: Group I(Protection) > Group II(Investment) = Group III(Savings)
- Female: Group II(Investment) > Group III(Savings) > Group I(Protection)

SMR-PCA (Male-2012-16)



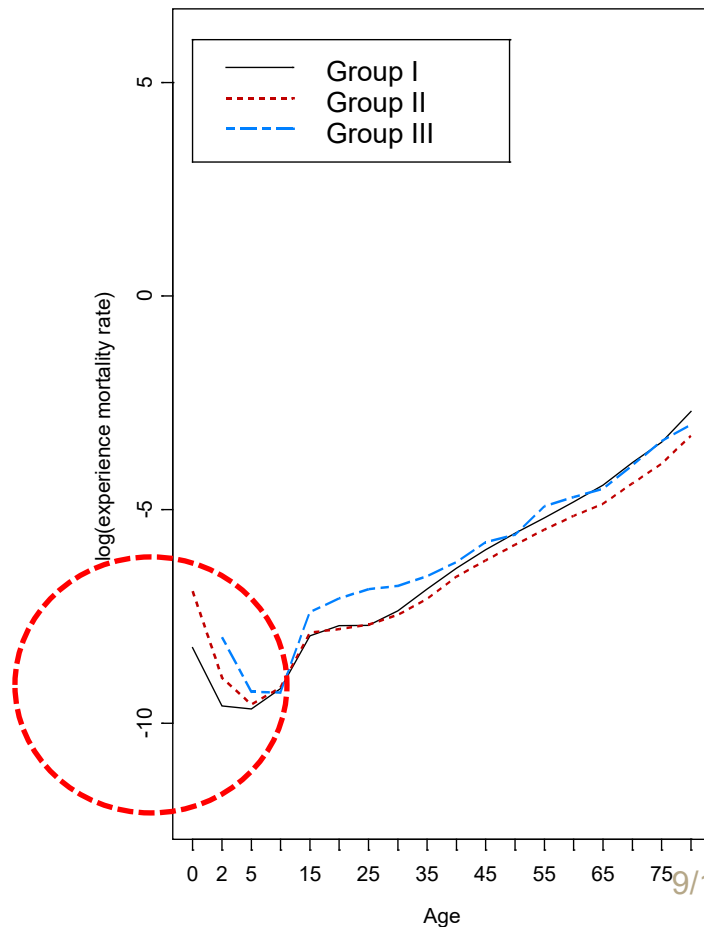
SMR-PCA (Female-2012-16)



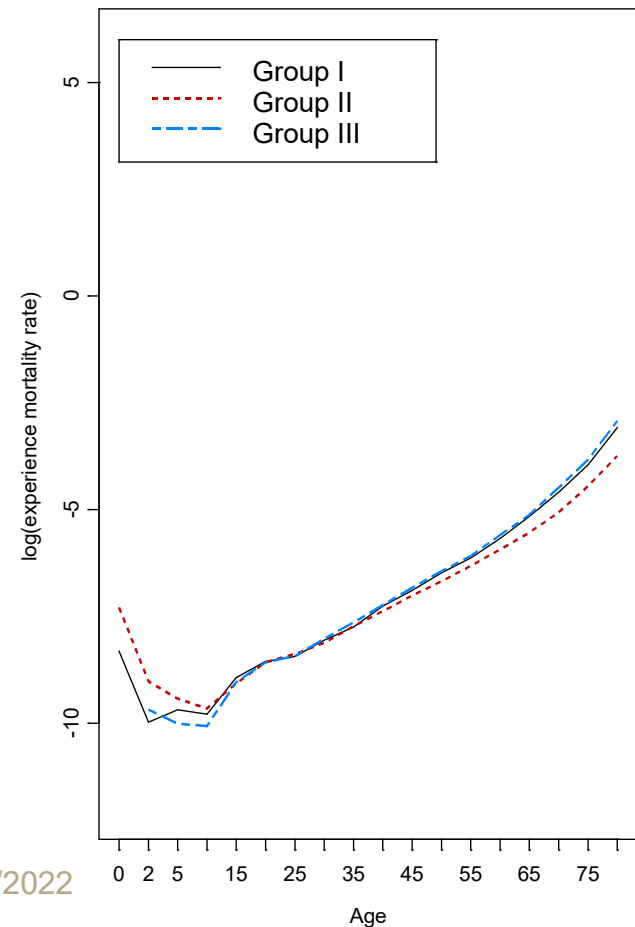
Experience Mortality Rates(CDR-Kmeans)

- Both Male and Female can only be clustered into two groups
- Male: Group II(Investment) \geq Group I(Protection) $>$ Group III(Savings)
- Female: Group III(Savings) \geq Group I(Protection) $>$ Group II(Investment)

CDR-Kmeans (Male-2012-16)



CDR-Kmeans(Female-2012-16)

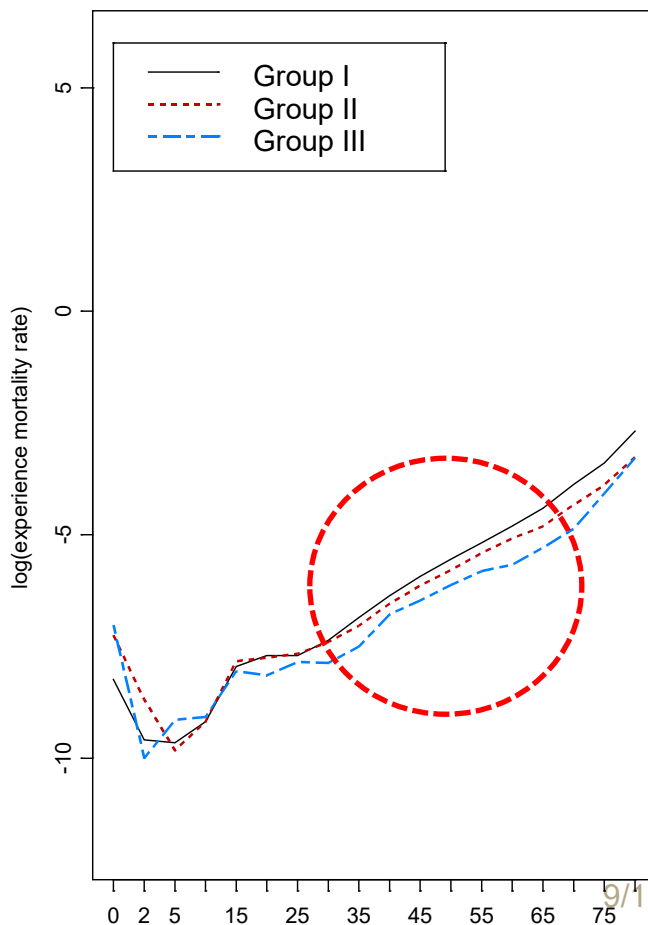


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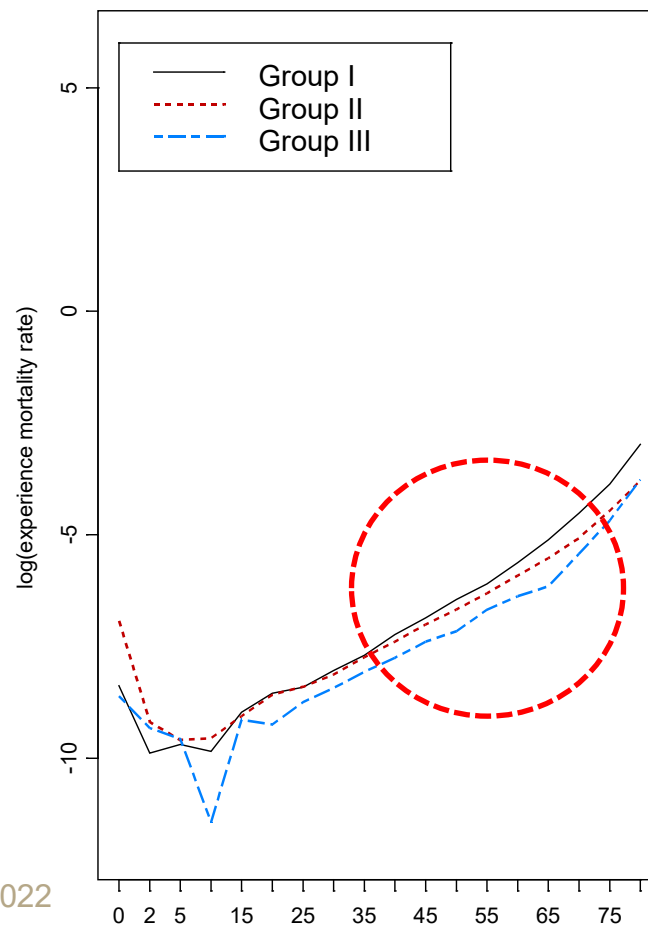
Experience Mortality Rates(SMR-Kmeans)

- Both Male and Female are clustered into three groups
- Male: **Group I(Protection) > Group II(Investment) > Group III(Savings)**
- Female: **Group I(Protection) > Group II(Investment) > Group III(Savings)**

SMR-Kmeans (Male-2012-16)



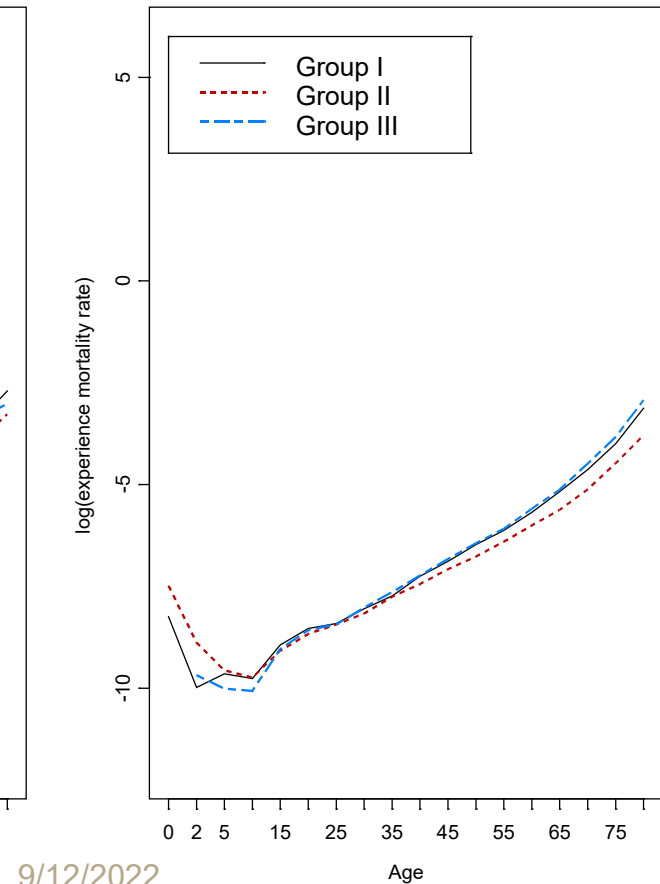
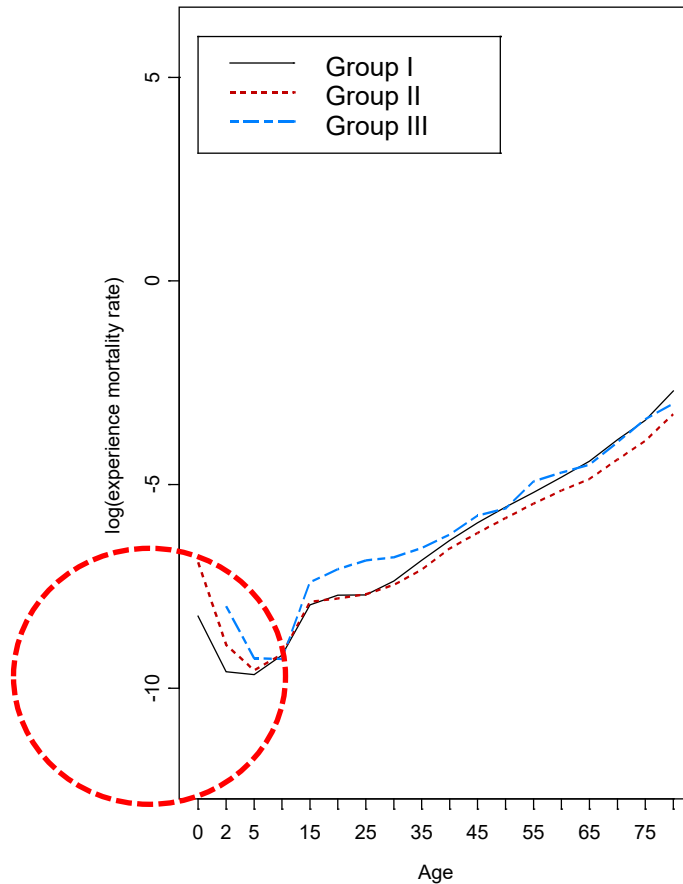
SMR-Kmeans(Female-2012-16)



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Experience Mortality Rates(CDR-Hierarchical Clustering)

- Both Male and Female can only be clustered into two groups
- Male: Group III(Savings) \geq Group I(Protection) $>$ Group II(Investment)
- Female: Group III(Savings) \geq Group I(Protection) $>$ Group II(Investment)

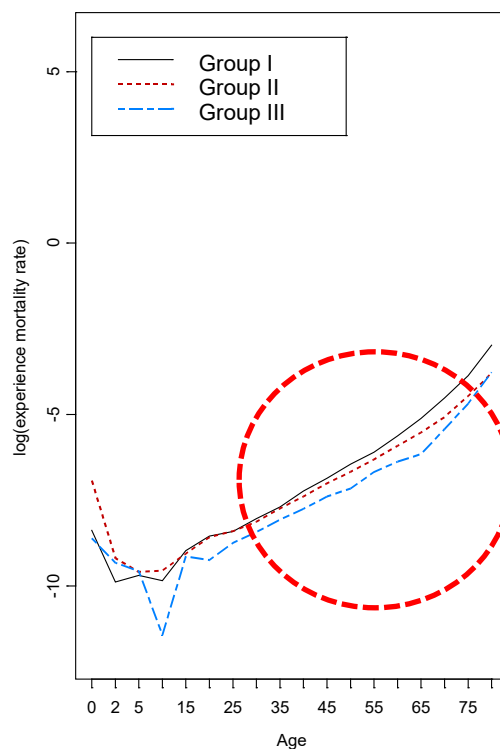
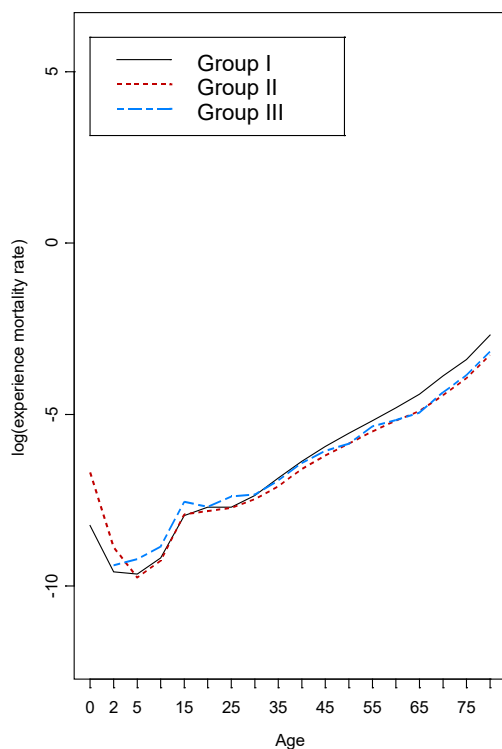


Experience Mortality Rates(SMR-Hierarchical Clustering)

- Female is more clearly to be clustered into three groups than male
- Male: Group I(Protection > Group II(Investment)= Group III(Savings)
- Female: Group I(Protection > Group II(Investment)> Group III(Savings)

SMR-Hierarchical Clustering(Male-2012-16)

SMR-Hierarchical Clustering(Female-2012-16)



Self-defined Classification Conditions

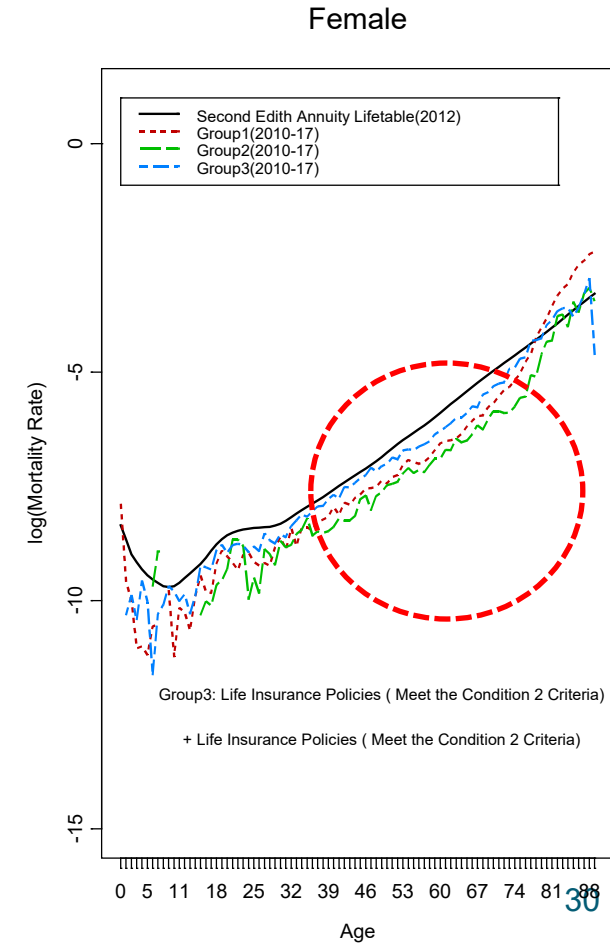
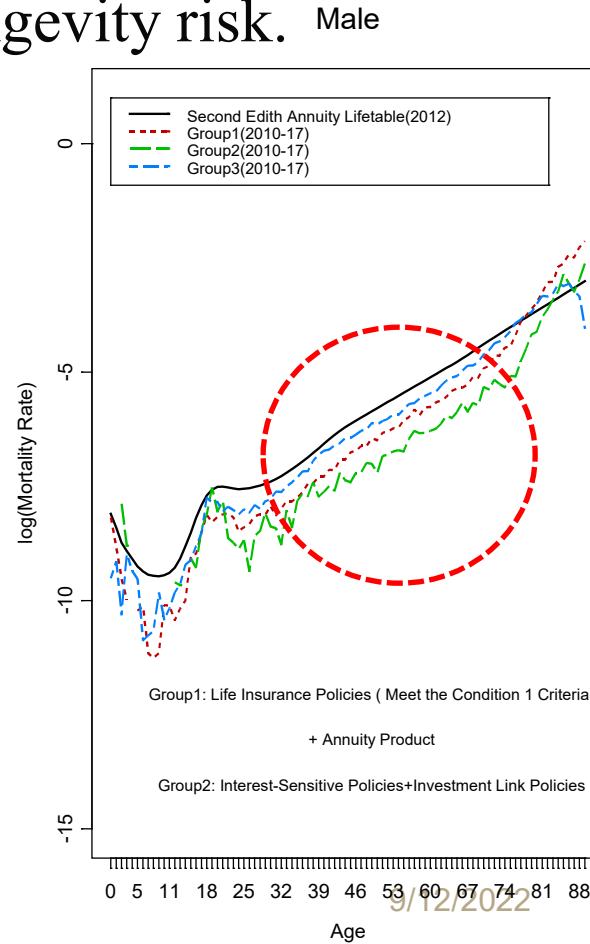
- Establish a suitable life table for higher survival liability and longevity risk
- Since Taiwanese people like the insurance policies serve as major tools for investments or savings, but poor sales of annuity products
- Yue J.C. and Huang H.C. (2011) found that principal repayment is highly correlated with mortality risk
- The Second Edit Annuity Table (2012) in Taiwan is constructed based on 2003-2007 the experience mortality rates of principal repayment whole life insurance
- ➔ We classify the mortality rates of existing annuity insurance and life insurance products with principal repayment into three Groups
- The criteria classification conditions are:
 - Condition 1: life insurance: $(\text{death benefit amount} / \text{total premium payable} \leq 0.5) + \text{annuity product}$
 - Condition 2: interest-sensitive policies+ investment link policies
 - Condition 3: life insurance: $\text{Annuity benefit Amount} / (\text{total premium payable} / \text{payment period}) > 1 + (\text{Maturity benefit Amount} / \text{total premium payable}) > 1$

Self-defined Classification Conditions

● Male: Group III > Group I > Group II

● Female: Group III > Group I > Group II

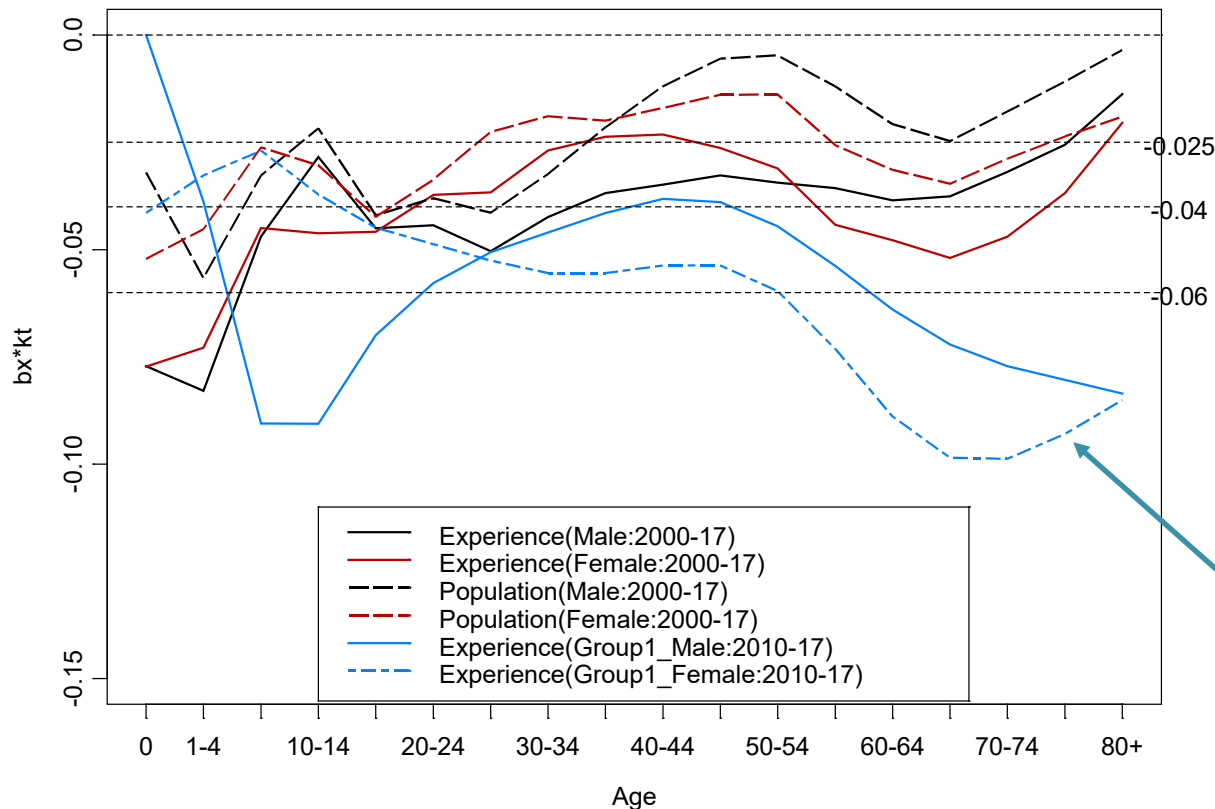
● The insurance companies can choose a more suitable mortality rate according to their own risk tolerance, experience mortality and other factors to control longevity risk.



Mortality Improvement Rates

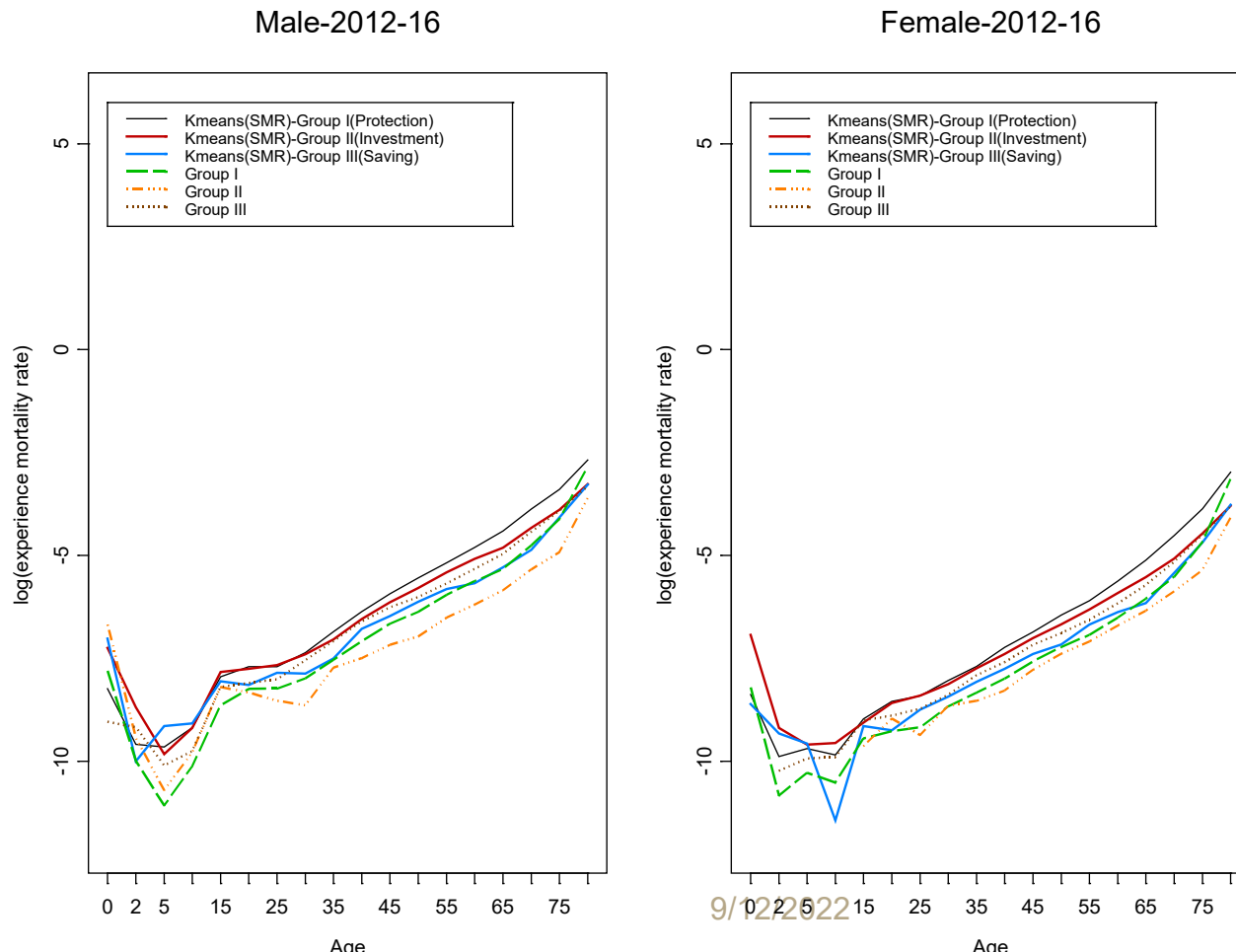
- We can use the mortality rates of **Group III, Group I, and Group II** to establish **low, medium, and high** level life tables with higher survival liability and longevity risk
- **Group I** has the largest Mortality improvement rates among Taiwan life insurance industry and Taiwan population(LC Model, 2000-17)

Mortality Improvement Rate in Taiwan



6 Types Classification Comparison

- **Kmeans(SMR) Group I(Protection) has highest mortality rate.**
- **Kmeans(SMR)Group I(Protection) >Kmeans(SMR) Group II(Investment) >=Group III>=Kmeans(SMR)Group III(Savings) >Group I>Group II**



Conclusion

- CDR is not suitable to compare the two different age distributions population, We propose that **use SMR as the index and K-means as clustering method** seems to **in coincidence with our intuitive thinking** :
The Mortality rates of Protection > Investment > Savings
(Investment and Savings Behavior are sometimes difficult to discriminate)
- The benefits of classification insurance products for insurance companies are:
 - **Develop different marketing strategies** for different consumers.
 - **Avoid moral hazard and to protect policyholder rights.**
 - Due to the small exposures, the mortality rate of some specific product may cause problems such as fluctuations phenomenon or having zero death in certain age groups → The proposed approach is **used the classified reference population** to smooth the experienced mortality rate



Thank you for your
attention.

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