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Longevity and Life Annuities Funding in Algeria

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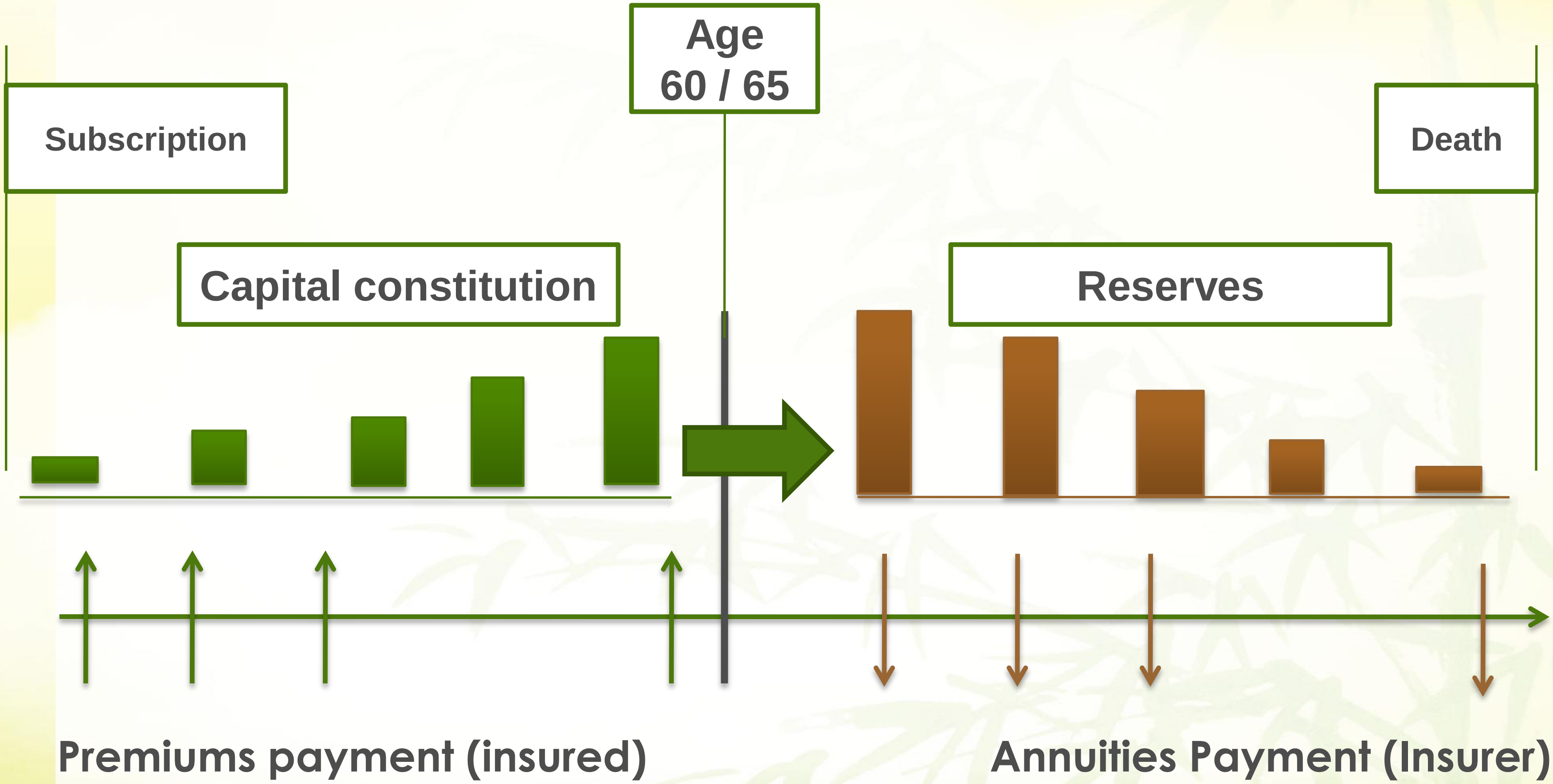
Introduction



Introduction

Introduction

Static Life-Table :

- One year mortality data
- **Assumption:** Mortality constancy
- In Algeria: Life table 1997 – 99 is still used for life annuities pricing / funding :

- End of the black decade
- High Mortality Level (WP: FLICI & HAMMOUDA, 2012)

Dynamic Life-Table :

- Historical mortality data
- **Assumption:** Mortality decrease

Introduction

- the amount of the Mathematical reserve depends on the life duration
- Now, Mortality is decreasing
- gap between Static life table and mortality evolution
- Dynamic life tables allow consider longevity

Mean Objective

- Construct dynamic life-table for the Algerian population
- But: **how to do for more accuracy?**

Data

- historical data : Algerian Life-tables as published by the NSO : 1977 - 2013: Males and females (*www.**ons.dz***)

x	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	0.126	0.11		0.099	0.094	0.083	0.08		0.077		0.062		0.055		0.053		0.053	0.052	0.052	0.052		0.05	0.04	0.035	0.04	0.03	0.03	0.029	0.03	0.03	0.02	0.024	0.023	0.022	0.022	0.021	0.021
1	0.057	0.045		0.056	0.053	0.048	0.023		0.021		0.014		0.01		0.009		0.009	0.009	0.01	0.009		0.01	0.01	0.006	0.01	0.01	0.005	0.005	0.00	0.00	0.00	0.004	0.004	0.004	0.004	0.004	0.004
5	0.017	0.019		0.011	0.01	0.01	0.013		0.011		0.009		0.007		0.005		0.005	0.005	0.005	0.005		0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
10	0.011	0.011		0.007	0.006	0.006	0.008		0.007		0.007		0.005		0.004		0.004	0.004	0.004	0.004		0.00	0.00	0.002	0.00	0.00	0.002	0.002	0.00	0.00	0.00	0.002	0.002	0.002	0.002	0.002	0.002
15	0.013	0.013		0.01	0.01	0.009	0.007		0.007		0.007		0.005		0.005		0.005	0.004	0.005	0.005		0.00	0.00	0.003	0.00	0.00	0.003	0.002	0.00	0.00	0.00	0.002	0.002	0.002	0.002	0.003	0.002
20	0.016	0.015		0.014	0.014	0.013	0.01		0.009		0.008		0.006		0.005		0.006	0.006	0.007	0.006		0.00	0.00	0.004	0.00	0.00	0.004	0.003	0.00	0.00	0.00	0.003	0.003	0.002	0.002	0.003	0.002
25	0.021	0.018		0.016	0.015	0.014	0.01		0.01		0.009		0.008		0.006		0.007	0.007	0.007	0.007		0.01	0.00	0.005	0.00	0.00	0.005	0.004	0.00	0.00	0.00	0.003	0.004	0.003	0.003	0.003	0.003
30	0.019	0.022		0.02	0.018	0.016	0.012		0.012		0.01		0.01		0.009		0.008	0.008	0.008	0.009		0.01	0.01	0.006	0.01	0.01	0.006	0.005	0.00	0.00	0.00	0.005	0.005	0.005	0.004	0.004	0.004
35	0.018	0.025		0.024	0.023	0.022	0.015		0.015		0.015		0.013		0.011		0.012	0.012	0.012	0.012		0.01	0.01	0.009	0.01	0.01	0.008	0.007	0.01	0.01	0.01	0.007	0.007	0.007	0.006	0.007	0.006
40	0.021	0.027		0.024	0.023	0.023	0.019		0.017		0.016		0.016		0.015		0.017	0.017	0.018	0.017		0.01	0.01	0.012	0.01	0.01	0.011	0.011	0.01	0.01	0.01	0.01	0.009	0.009	0.008	0.009	0.009
45	0.027	0.031		0.027	0.026	0.024	0.023		0.02		0.019		0.019		0.018		0.019	0.019	0.021	0.022		0.02	0.02	0.017	0.02	0.01	0.015	0.014	0.01	0.01	0.01	0.013	0.013	0.013	0.013	0.013	0.012
50	0.036	0.041		0.04	0.037	0.035	0.031		0.032		0.03		0.028		0.027		0.03	0.031	0.029	0.029		0.03	0.02	0.022	0.02	0.02	0.021	0.021	0.02	0.02	0.02	0.019	0.02	0.018	0.018	0.018	0.017
55	0.055	0.062		0.058	0.055	0.052	0.049		0.051		0.051		0.046		0.043		0.047	0.045	0.045	0.044		0.04	0.03	0.032	0.03	0.03	0.028	0.028	0.03	0.03	0.03	0.026	0.03	0.028	0.027	0.027	0.025
60	0.091	0.076		0.088	0.083	0.079	0.076		0.069		0.076		0.054		0.071		0.05	0.098	0.075	0.078		0.07	0.05	0.054	0.05	0.05	0.049	0.047	0.05	0.04	0.04	0.045	0.045	0.042	0.041	0.042	0.038
65	0.145	0.102		0.137	0.135	0.129	0.123		0.12		0.109		0.141		0.117		0.099	0.121	0.108	0.107		0.09	0.08	0.079	0.08	0.08	0.074	0.072	0.08	0.07	0.07	0.068	0.068	0.064	0.062	0.064	0.064
70	0.248	0.16		0.196	0.186	0.177	1		1		1		0.195		0.193		0.193	0.188	0.176	0.173		0.16	0.14	0.135	0.13	0.13	0.125	0.123	0.12	0.11	0.12	0.12	0.123	0.111	0.106	0.109	0.105
75	0.377	0.314		0.317	0.296	0.277							0.305		0.404		1	1	1	1		0.26	0.23	0.225	0.21	0.21	0.213	0.199	0.21	0.19	0.19	0.193	0.205	0.194	0.19	0.192	0.179
80	1	1		1	1	1							1		1							1	1	1	1	1	1	1	1	1	1	1	1	0.323	0.314	0.322	0.308
85																																		1	1	1	1

- Missing calendar years life tables and those were closed out before the age of 80, were completed by another WP (FLICI, 2014 – b)

Data – mortality surfaces

Annuitant's portfolio in pay: we consider only the age range (60 years and over)

Single years life table : Karup – king interpolation formula with 03 diferences

Ln (Ux)

Methodology

• Single year mortality surface (population aged 60 years and over)

•Lee Carter model LC (Lee & Carter, 1992)
•Lee Carter model with 2 Compenents LC2(Renshaw & haberman, 2003 & 2006)
•Lee Carter model with 3 Compenents LC3(Booth & al. 2002)
•Lee Carter model with 4 Compenets LC4

• Mortality trend projecting (ARMA – Siu-Hang Li & al. or Linear: Lee & carter)

•Old ages mortality extending (Coale & Kisker, 1990, Nan Li, 2011)

•Life annuities reserving

Lee Carter Model

- Principal idea of LC Model : extrapolate the historical mortality trend in the future. (Lee and Carter, 1992)

- decomposition on the ln mortality rate on three components :

$$ln(\mu_{xt}) = \alpha_x + \beta_x k_t + \varepsilon_{xt}$$

α_x *:* represents the time average of *ln* (at the age x ;
κ_t : general mortality trends index ;
β_x : Sensitivity of the age-x mortality compared with the general trend of mortality.
$\varepsilon_{x;t}$: error.

- We work on ln (qxt) : Girosi & King, Cairns, 2006, Planchet 2010 ((1-qx)/qx)
- Lead to more accurate results compared with the use of ln(Uxt)

Multi components Lee Carter Models

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- **Principal :**
- Consider more than one component to reduce the information loss.
- Improve the goodness of the fitting

- Booth & al, 2002 (j=5)
- Renshaw & Haberman, 2003 : two components – Added extra time factor (j=2)
- Cohort effect (renshaw & haberman, 2006)
- Cairns & al. 2006 : old age effect
- Lundestrom & Quist, 2004 (Multi component comparaison – sweden)

- Alho, 2007 : multi factor analysis)

$$ln(\mu_{xt}) = \alpha_x + \sum_{j=1}^{J} \beta_x^{(j)} k_t^{(j)} + \varepsilon_{xt}$$

Lee Carter Model - Implimentation

- Estimate alpha-parameter : Average by age of the Ln(Ux)

$$\alpha_x = \prod_{t=1}^{T} \ln\left(u_{xt}\right)^{\frac{1}{T}}$$

- genarally, we use the global mortality surface to estimate this parameters,

- But, Lee-Carter (1992) introduced the possibility to use only the recents years to escape for some irregularities in historical data.

Lee Carter Model - Implimentation

- Decomposition of the Risidual on two components: Betta and Kappa

$$\ln(u_{x,t}) - \alpha_x = \beta_x * k_t$$

•Two steps decomposition process:

•In the original paper (Lee-Carter, 1992), authors proposed a method based on the SVD (Singular Values Decomposition) by using the Principal Components Analysis (PCA). With as a constraints:

$$\sum_{t=1}^{T} k_t = 0 \quad and \sum_{x=1}^{X} b_x = 1$$

•Wilmouth, 1993, proposed a decomposition process based on Weighted SVD. He considered the survival numbers at each age categorie;

•Theses conditions are not necessary (wilmouth, 1993)

Lee Carter Model - Implimentation

•For the present work, we propose a decomposition process based on Linear programation with XL-Solver

•The optimation criterion is MPAD (Mean Percentage Absolute Deviation on qx as discussed by (FLICI, 2014: WP):

•The objective function:

$$Min\ MPAD = \frac{1}{(T-t)*(X-x)} \sum_{t=1977,x=60}^{2013,79} \left|\ln(q_{x,t}) - \exp\left(\alpha_x - \beta'_x * k'_t\right)\right|$$

• the ignorance of the constraint allow to improve the fitting quality : the solver need a starting values for kt and bx

Decomposition with XL-Solver

	Crude										
qx	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
60	-3,9	-3,9	-3,9	-3,8	-3,9	-3,9	-4,2	-4,3	...	...	...
61	-3,8	-3,8	-3,8	-3,7	-3,8	-3,8	-4,1	-4,2	...	...	...
62	-3,7	-3,7	-3,7	-3,7	-3,8	-3,8	-4	-4,1	...	...	...
63	-3,6	-3,7	-3,7	-3,6	-3,7	-3,7	-3,9	-4	...	...	...
64	-3,5	-3,6	-3,6	-3,5	-3,6	-3,6	-3,8	-3,9	...	...	...
65	-3,4	-3,6	-3,5	-3,5	-3,5	-3,5	-3,6	-3,8	...	...	...
66	...	...	...	...	...	...	...	...	...	...	...
67	...	...	...	...	...	...	...	...	...	...	...
68	...	...	...	...	...	...	...	...	...	...	...
Kt	1,3	0,8	0,7	0,6	0,4	0,2	0,6	0,5	...	...	...

	MPAD										
qx	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
60	6%	1%	2%	5%	7%	8%	4%	5%	...	...	...
61	5%	1%	1%	5%	6%	8%	4%	6%	...	...	...
62	5%	1%	1%	5%	6%	7%	4%	6%	...	...	...
63	5%	0%	1%	5%	6%	7%	3%	6%	...	...	...
64	5%	1%	1%	4%	6%	7%	2%	5%	...	...	...
65	5%	2%	1%	4%	6%	8%	0%	4%	...	...	...
66	...	...	...	...	...	...	...	...	...	...	...
67	...	...	...	...	...	...	...	...	...	...	...
68	...	...	...	...	...	...	...	...	...	...	...

Mean MPAD: 4%

	Crude												
qx	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	bx	alpha
60	-3,6	-3,9	-3,9	-4	-4,1	-4,2	-4	-4	...	...	...	0,5	-4,33792034
61	-3,6	-3,8	-3,9	-3,9	-4,1	-4,1	-4	-4	...	...	...	0,5	-4,2604582
62	-3,5	-3,7	-3,8	-3,9	-4	-4,1	-3,9	-3,9	...	...	...	0,5	-4,17590976
63	-3,4	-3,7	-3,7	-3,8	-3,9	-4	-3,8	-3,8	...	...	...	0,5	-4,08523413
64	-3,3	-3,6	-3,6	-3,7	-3,8	-3,9	-3,7	-3,7	...	...	...	0,5	-3,99106591
65	-3,2	-3,5	-3,5	-3,6	-3,7	-3,8	-3,6	-3,6	...	...	...	0,5	-3,91283803
66	...	...	...	...	...	...	...	...	...	...	...	...	...
67	...	...	...	...	...	...	...	...	...	...	...	...	...
68	...	...	...	...	...	...	...	...	...	...	...	...	...

Feuil1 Feuil2 Feuil3

Paramètres du solveur

Cellule cible à définir: $O$14

Égale à: Max / Min / Valeur: 0

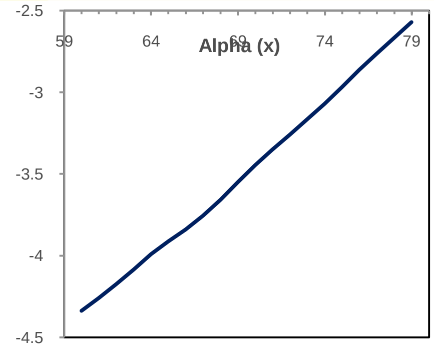
Cellules variables: $B$13:$I$13;$N$17:$N$22

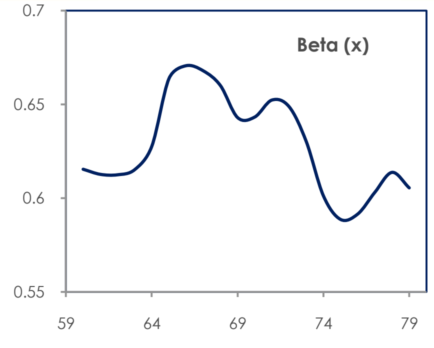
Contraintes:

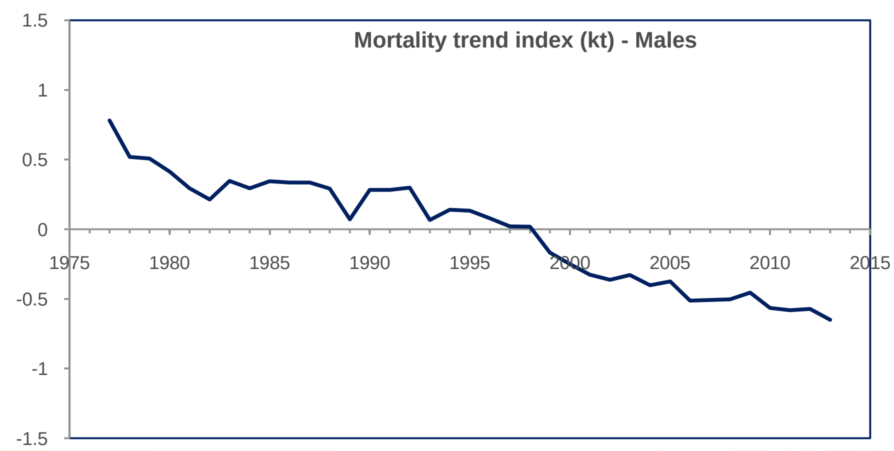
Résoudre | Fermer | Proposer | Options | Ajouter | Modifier | Supprimer | Rétablir | Aide

LC– estimation results

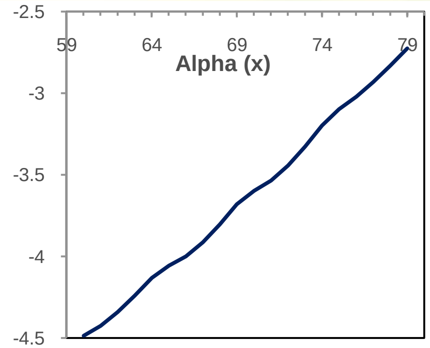
Males

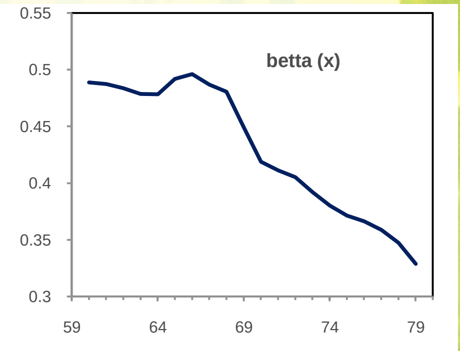


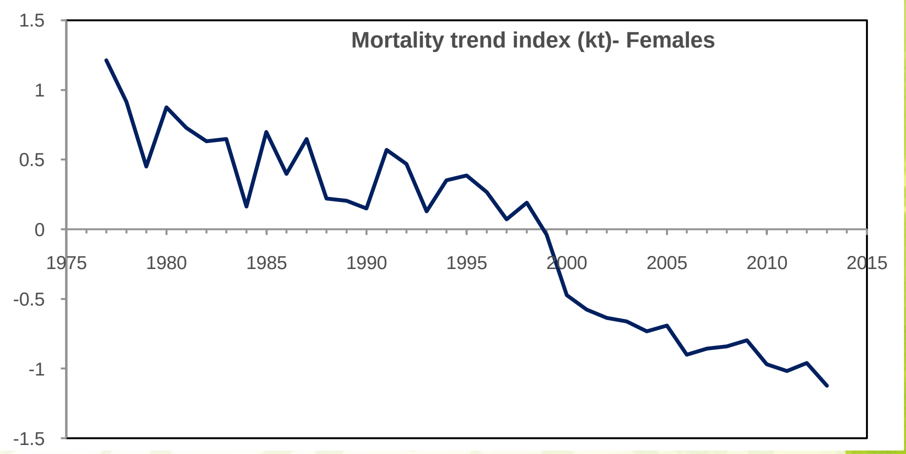




Females







Errors distribution

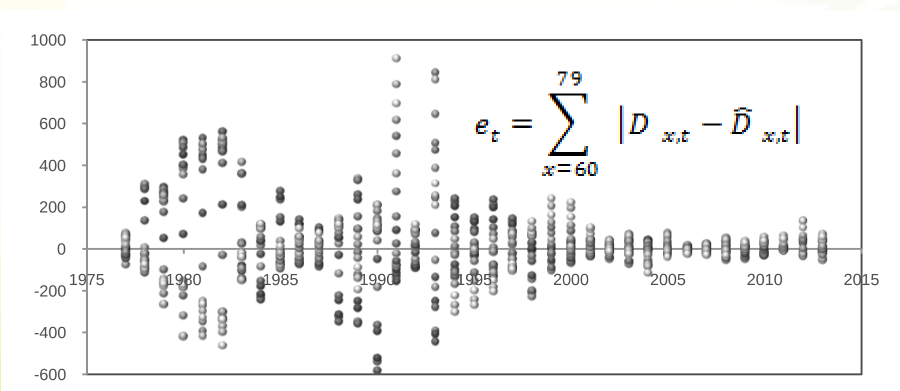
Males

MPAD(x,t)

MPAD	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
60	0.00%	14.21%	14.27%	23.64%	24.28%	25.99%	7.22%	12.99%	7.49%	3.25%	2.18%	19.00%	23.09%	34.54%	11.38%	5.71%	23.02%	9.57%	6.16%	9.09%
61	0.13%	14.21%	13.25%	22.64%	22.62%	24.60%	9.84%	16.35%	12.24%	6.44%	4.87%	25.18%	32.04%	49.70%	9.44%	6.13%	37.90%	13.04%	8.30%	12.92%
62	0.00%	12.90%	12.21%	21.22%	21.18%	23.27%	8.77%	16.41%	13.42%	7.20%	5.46%	25.57%	30.81%	51.18%	7.67%	5.83%	41.41%	13.31%	8.53%	13.34%
63	0.39%	10.38%	11.16%	19.39%	19.96%	22.02%	4.85%	13.75%	11.78%	5.99%	4.32%	21.13%	21.70%	40.71%	6.12%	4.97%	34.07%	10.95%	7.17%	11.01%
64	1.36%	6.53%	9.98%	17.14%	18.93%	20.87%	0.71%	9.33%	7.50%	2.99%	1.61%	13.75%	8.87%	24.57%	4.83%	3.78%	20.53%	6.16%	4.48%	6.17%
65	2.82%	1.64%	9.77%	16.17%	19.81%	21.67%	7.60%	5.41%	2.76%	0.46%	1.62%	7.43%	3.15%	12.12%	4.51%	2.75%	12.73%	0.00%	1.51%	0.00%
66	1.77%	0.85%	10.96%	16.62%	21.29%	22.96%	12.89%	2.45%	0.90%	1.63%	2.74%	3.30%	10.02%	5.29%	3.47%	1.32%	9.79%	3.96%	0.00%	4.07%
67	1.20%	2.24%	10.37%	15.18%	20.19%	21.76%	14.23%	0.73%	0.41%	2.29%	3.25%	0.93%	12.50%	1.50%	1.92%	0.46%	5.04%	5.59%	0.81%	5.73%
68	1.24%	2.66%	8.07%	11.84%	16.62%	18.19%	12.37%	0.06%	1.24%	2.53%	3.26%	0.01%	11.74%	0.01%	0.06%	0.14%	0.63%	4.99%	0.98%	5.09%
69	1.23%	1.80%	4.45%	6.85%	10.63%	12.28%	7.69%	0.00%	1.33%	2.11%	2.56%	0.01%	8.29%	0.00%	2.23%	0.00%	6.66%	2.47%	0.44%	2.51%
70	0.82%	0.60%	0.03%	0.01%	2.65%	4.77%	2.04%	0.48%	1.53%	1.74%	1.79%	0.56%	5.21%	0.79%	4.07%	0.41%	14.03%	0.90%	0.80%	0.69%
71	0.00%	0.07%	3.26%	5.65%	3.78%	1.18%	1.39%	1.40%	1.92%	1.59%	1.31%	1.70%	4.21%	2.44%	5.53%	1.05%	19.38%	2.87%	1.63%	2.47%
72	0.58%	0.39%	4.95%	8.49%	7.41%	4.86%	3.15%	1.89%	1.95%	1.28%	0.91%	2.26%	3.17%	3.13%	7.28%	1.47%	21.33%	3.24%	1.54%	2.91%
73	1.19%	0.57%	4.95%	8.27%	7.93%	6.04%	3.16%	2.13%	1.54%	0.70%	0.45%	2.42%	2.08%	3.10%	9.40%	1.81%	20.73%	2.28%	0.67%	2.22%
74	1.49%	0.44%	3.54%	5.37%	5.62%	4.86%	1.65%	2.07%	0.81%	0.04%	0.00%	2.14%	0.94%	2.35%	11.81%	2.00%	17.64%	0.01%	0.97%	0.47%
75	1.31%	0.01%	2.20%	2.51%	3.13%	3.32%	0.13%	1.80%	0.30%	0.53%	0.19%	1.67%	0.00%	1.36%	13.85%	2.01%	14.23%	2.40%	2.65%	1.35%
76	1.44%	0.19%	1.72%	1.35%	2.41%	3.23%	0.46%	1.78%	0.03%	0.93%	0.42%	1.53%	0.84%	0.92%	15.75%	2.15%	12.70%	3.92%	3.80%	2.45%
77	0.92%	0.80%	2.09%	1.11%	2.73%	4.19%	0.39%	1.65%	0.08%	1.15%	0.47%	1.27%	2.02%	0.39%	17.90%	2.16%	11.57%	5.54%	5.14%	3.52%
78	0.57%	1.29%	2.73%	1.28%	3.70%	5.93%	0.05%	1.70%	0.23%	1.54%	0.71%	1.21%	3.47%	0.06%	20.54%	2.35%	10.91%	7.12%	6.52%	4.51%
79	1.50%	0.87%	2.87%	1.18%	4.88%	8.22%	0.00%	2.40%	1.04%	2.67%	1.69%	1.80%	5.15%	0.36%	24.15%	3.20%	10.71%	8.52%	7.81%	5.34%

MPAD	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
60	5.49%	0.77%	2.31%	0.75%	0.26%	1.21%	0.01%	0.64%	2.98%	1.49%	1.31%	1.22%	0.90%	2.62%	0.03%	2.96%	1.53%
61	8.42%	1.72%	0.18%	2.49%	3.03%	1.34%	3.09%	2.86%	2.54%	0.75%	1.99%	3.27%	1.43%	3.14%	0.16%	3.48%	1.56%
62	8.75%	1.83%	0.83%	2.72%	3.81%	2.10%	3.89%	3.58%	2.15%	0.20%	1.89%	3.60%	1.20%	3.31%	0.39%	3.26%	1.36%
63	6.98%	0.00%	0.00%	1.72%	3.01%	1.46%	2.89%	3.13%	1.81%	0.20%	1.16%	2.56%	0.35%	3.19%	0.64%	2.46%	0.96%
64	3.45%	3.44%	1.80%	0.00%	1.28%	0.05%	0.75%	2.14%	1.10%	0.05%	0.42%	0.87%	0.53%	2.30%	0.35%	0.68%	0.18%
65	1.01%	8.56%	4.05%	1.80%	0.17%	1.31%	1.69%	1.89%	0.08%	0.97%	0.05%	0.79%	1.23%	0.96%	0.66%	2.28%	2.69%
66	4.00%	12.34%	5.89%	3.53%	1.60%	2.88%	3.95%	1.15%	0.21%	0.35%	1.37%	3.03%	2.82%	1.48%	0.00%	3.08%	3.09%
67	4.99%	12.96%	6.19%	4.10%	2.24%	3.26%	4.48%	0.59%	0.00%	0.00%	1.84%	3.64%	3.30%	1.41%	0.30%	3.10%	2.82%
68	4.16%	10.82%	5.13%	3.59%	2.11%	2.54%	3.44%	0.28%	0.55%	0.00%	1.41%	2.74%	2.72%	0.77%	0.16%	2.58%	2.13%
69	1.85%	6.67%	3.12%	2.34%	1.50%	1.16%	1.40%	0.00%	1.17%	0.02%	0.54%	1.00%	1.57%	0.01%	0.00%	1.37%	0.80%
70	0.95%	2.61%	1.53%	1.64%	1.23%	0.38%	0.88%	0.10%	2.19%	0.06%	0.45%	0.92%	0.50%	0.79%	0.01%	0.40%	1.00%
71	2.60%	0.34%	0.75%	1.51%	1.33%	1.25%	2.18%	0.26%	2.94%	0.00%	0.95%	1.97%	0.01%	1.27%	0.15%	1.66%	2.33%
72	3.11%	0.90%	0.10%	0.89%	1.05%	1.58%	2.64%	0.52%	3.07%	0.04%	1.10%	2.31%	0.32%	1.54%	0.03%	1.77%	2.58%
73	2.66%	1.33%	0.92%	0.00%	0.63%	1.27%	2.24%	1.10%	2.49%	0.33%	0.71%	1.82%	0.27%	1.34%	0.00%	1.21%	2.28%
74	1.35%	1.08%	1.79%	1.17%	0.00%	0.52%	1.19%	1.84%	1.39%	0.70%	0.02%	0.73%	0.00%	0.88%	0.06%	0.03%	1.43%
75	0.00%	0.66%	2.57%	2.28%	0.69%	0.01%	0.33%	2.27%	0.57%	0.76%	0.43%	0.02%	0.03%	0.74%	0.41%	1.32%	0.33%
76	0.75%	0.65%	3.21%	3.05%	1.14%	0.27%	0.09%	2.62%	0.11%	0.81%	0.65%	0.39%	0.00%	0.72%	0.64%	2.07%	0.26%
77	1.38%	0.93%	4.18%	4.15%	1.92%	0.13%	0.10%	2.66%	0.03%	0.43%	0.38%	0.24%	0.49%	1.24%	1.38%	3.23%	1.29%
78	1.90%	1.49%	5.28%	5.30%	2.68%	0.01%	0.08%	2.83%	0.09%	0.17%	0.19%	0.13%	0.94%	1.68%	1.98%	4.20%	2.09%
79	2.29%	2.39%	6.31%	6.20%	2.95%	0.44%	0.56%	3.80%	0.87%	0.86%	0.91%	0.88%	0.63%	1.15%	1.56%	4.17%	1.66%

MPAD	4.43%

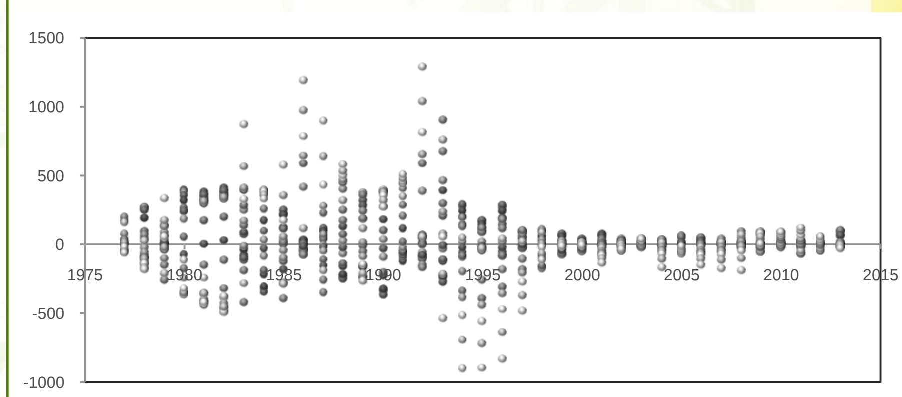


Females

MPAD	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
60	0.01%	13.01%	0.65%	18.75%	19.28%	21.09%	5.58%	22.07%	7.02%	0.03%	3.35%	14.99%	15.21%	23.69%	9.02%	0.62%	11.47%	13.14%	7.91%	13.07%
61	0.00%	13.22%	0.38%	17.91%	17.81%	19.90%	8.02%	34.23%	11.75%	1.67%	6.13%	22.01%	23.01%	37.15%	6.94%	3.50%	23.81%	16.69%	10.30%	16.96%
62	0.00%	11.82%	0.43%	16.42%	16.35%	18.52%	6.59%	35.44%	12.61%	2.09%	6.55%	22.57%	21.26%	38.54%	5.18%	4.04%	26.22%	16.63%	10.33%	17.03%
63	0.00%	9.11%	0.28%	14.43%	15.00%	17.05%	2.41%	27.39%	10.55%	1.48%	5.12%	17.84%	12.64%	29.63%	3.79%	2.78%	19.63%	13.73%	8.50%	14.11%
64	0.55%	5.01%	1.41%	11.80%	13.58%	15.40%	2.90%	15.05%	5.85%	0.03%	2.05%	10.25%	1.43%	16.13%	2.92%	0.00%	8.50%	8.36%	5.15%	8.62%
65	1.90%	0.07%	4.05%	10.78%	14.29%	15.93%	10.09%	7.06%	2.17%	1.64%	0.13%	5.13%	8.62%	7.50%	3.42%	2.95%	3.24%	2.02%	1.70%	2.22%
66	2.06%	2.94%	6.28%	10.86%	15.43%	16.95%	15.05%	3.42%	1.05%	2.30%	0.55%	2.64%	14.25%	3.62%	3.34%	4.27%	1.70%	1.99%	0.12%	1.84%
67	1.43%	4.01%	5.89%	9.06%	13.79%	15.20%	15.16%	0.00%	0.81%	2.27%	1.72%	0.15%	15.89%	0.01%	1.79%	4.69%	2.60%	3.40%	0.96%	3.33%
68	1.72%	4.52%	2.90%	4.67%	9.00%	10.43%	10.80%	2.81%	4.08%	2.16%	4.24%	1.88%	14.44%	2.99%	0.03%	4.92%	8.06%	2.89%	1.38%	2.80%
69	0.74%	1.90%	0.82%	0.57%	3.41%	4.72%	4.18%	5.49%	6.23%	0.81%	5.74%	4.12%	11.20%	5.77%	3.48%	3.56%	13.94%	0.00%	0.30%	0.05%
70	4.72%	2.06%	5.50%	3.12%	1.77%	0.25%	5.77%	8.26%	10.39%	3.02%	10.28%	5.56%	9.68%	8.83%	6.40%	6.43%	21.73%	5.82%	3.95%	5.40%
71	6.27%	3.54%	9.37%	6.86%	6.23%	4.33%	14.43%	10.35%	15.10%	5.93%	15.33%	6.46%	9.55%	11.16%	7.70%	10.22%	26.81%	9.28%	6.68%	8.67%
72	5.83%	3.03%	10.13%	9.42%	9.55%	7.86%	15.54%	11.31%	15.06%	3.29%	14.17%	7.80%	7.97%	12.04%	8.86%	7.21%	26.89%	8.04%	5.07%	7.54%
73	4.79%	1.75%	7.91%	9.89%	10.81%	9.95%	9.67%	11.49%	10.64%	3.18%	7.90%	9.50%	5.49%	11.92%	10.23%	0.48%	23.29%	3.35%	0.27%	3.13%
74	2.86%	0.42%	4.00%	9.07%	10.63%	10.94%	0.67%	11.16%	4.22%	10.85%	0.31%	11.30%	2.44%	11.13%	11.52%	9.46%	16.50%	4.45%	7.39%	4.09%
75	1.94%	1.49%	2.13%	9.02%	11.11%	12.11%	3.34%	11.28%	1.07%	14.75%	4.35%	12.52%	0.54%	11.00%	12.52%	13.93%	12.74%	9.10%	12.05%	8.35%
76	1.63%	1.89%	1.70%	9.72%	12.27%	13.64%	4.36%	11.66%	0.02%	16.47%	5.86%	13.30%	0.58%	11.29%	13.22%	15.85%	11.63%	11.08%	14.20%	10.14%
77	0.85%	2.82%	0.26%	9.11%	12.06%	14.09%	8.20%	11.67%	2.99%	19.71%	9.44%	14.33%	2.19%	11.06%	14.08%	19.52%	7.45%	15.96%	18.98%	14.55%
78	0.00%	3.92%	3.34%	7.30%	10.56%	13.45%	13.72%	11.48%	7.29%	23.78%	14.24%	15.57%	4.05%	10.53%	15.14%	24.10%	0.45%	23.35%	25.98%	21.18%
79	0.19%	4.55%	7.24%	4.16%	7.72%	11.56%	20.06%	11.29%	12.49%	28.25%	19.74%	17.05%	5.85%	9.91%	16.61%	29.09%	9.36%	32.87%	34.72%	29.64%

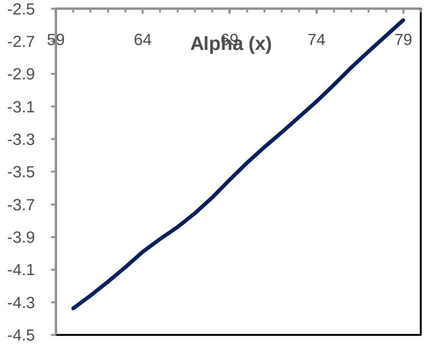
MPAD	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
60	3.52%	3.86%	2.33%	1.09%	1.91%	6.47%	1.39%	0.01%	1.38%	0.06%	1.19%	1.29%	0.08%	2.27%	2.89%	1.49%	1.10%
61	6.47%	6.69%	5.24%	3.41%	5.81%	3.48%	1.20%	2.51%	0.28%	0.19%	0.09%	1.11%	0.02%	1.73%	2.68%	2.24%	2.81%
62	7.03%	6.57%	5.63%	3.69%	6.86%	1.69%	1.96%	3.14%	0.10%	0.17%	0.28%	1.80%	0.60%	0.96%	1.92%	2.03%	2.71%
63	5.72%	4.12%	4.04%	2.36%	5.73%	0.92%	1.25%	2.29%	0.07%	0.00%	0.02%	1.11%	1.59%	0.00%	0.72%	1.04%	1.28%
64	3.10%	0.17%	1.10%	0.26%	3.41%	0.39%	0.00%	0.91%	1.19%	0.95%	0.04%	0.07%	2.19%	0.31%	0.00%	0.20%	1.74%
65	0.42%	5.85%	2.10%	1.85%	1.75%	0.76%	0.95%	0.20%	3.46%	2.76%	0.25%	1.16%	3.48%	0.31%	0.00%	0.01%	5.85%
66	1.03%	9.72%	4.04%	3.38%	0.81%	1.54%	1.72%	1.16%	4.60%	3.49%	0.02%	2.41%	5.19%	1.07%	0.66%	0.62%	7.84%
67	1.48%	10.22%	4.54%	3.78%	0.10%	1.74%	1.94%	1.42%	4.25%	3.33%	0.00%	2.29%	4.87%	1.33%	1.28%	1.13%	7.88%
68	1.17%	8.18%	3.77%	2.62%	0.35%	2.24%	0.88%	0.20%	3.61%	3.58%	1.19%	0.11%	2.05%	0.00%	0.55%	0.29%	7.70%
69	0.04%	4.00%	2.18%	1.72%	0.21%	1.31%	0.75%	0.03%	1.04%	1.79%	0.89%	1.03%	0.00%	0.24%	1.64%	1.13%	4.57%
70	2.91%	0.54%	0.50%	1.16%	0.69%	0.27%	1.26%	0.38%	2.01%	0.01%	0.72%	2.34%	1.40%	1.68%	4.37%	3.17%	0.88%
71	5.01%	3.03%	0.56%	0.35%	0.30%	0.51%	0.89%	1.51%	3.10%	0.08%	1.74%	4.20%	3.11%	1.66%	5.22%	3.53%	0.03%
72	4.26%	3.50%	0.89%	0.20%	0.31%	0.69%	0.24%	1.72%	3.16%	0.00%	1.90%	4.55%	4.05%	0.72%	4.20%	2.73%	0.04%
73	1.39%	2.60%	0.62%	0.13%	1.08%	0.32%	0.00%	0.62%	3.02%	0.93%	0.70%	3.09%	3.75%	0.00%	2.79%	1.96%	0.28%
74	2.99%	0.75%	0.09%	0.03%	1.93%	0.01%	0.40%	0.86%	2.28%	1.83%	0.86%	0.93%	3.09%	1.08%	0.67%	0.71%	0.01%
75	5.42%	0.01%	0.04%	0.02%	2.35%	0.11%	0.71%	1.58%	1.94%	2.33%	1.64%	0.12%	2.93%	1.72%	0.46%	0.00%	0.05%
76	6.42%	0.00%	0.06%	0.19%	2.50%	0.12%	0.96%	1.76%	1.89%	2.56%	1.86%	0.37%	3.12%	2.10%	0.98%	0.36%	0.01%
77	8.79%	0.78%	0.07%	0.18%	2.89%	0.25%	1.18%	2.50%	1.54%	3.04%	2.66%	1.48%	2.82%	2.58%	1.89%	0.91%	0.03%
78	12.17%	2.05%	0.32%	0.00%	3.52%	0.53%	1.30%	3.72%	1.06%	3.81%	3.98%	3.33%	2.05%	2.96%	2.90%	1.44%	0.00%
79	16.23%	3.47%	0.59%	0.49%	4.53%	1.20%	1.04%	5.61%	0.81%	5.21%	6.06%	6.12%	0.61%	2.81%	3.43%	1.47%	0.64%

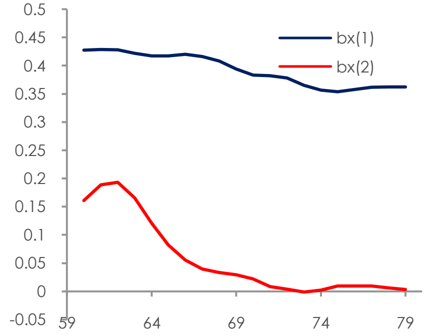
MPAD	5.78%

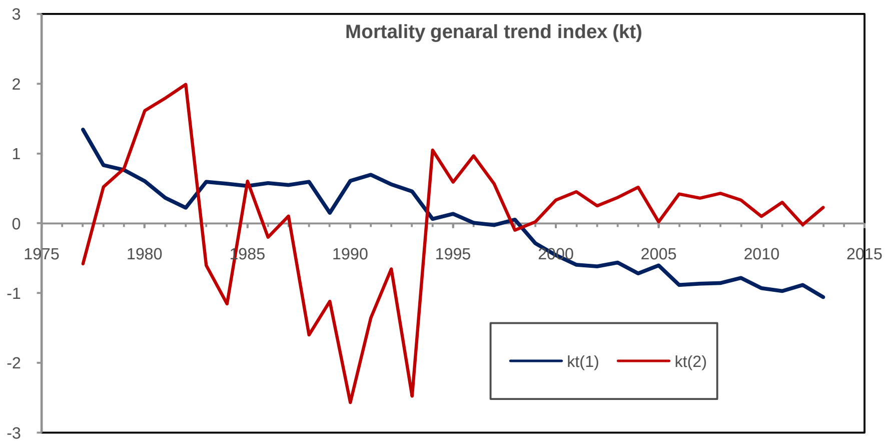


LC2 – estimation results

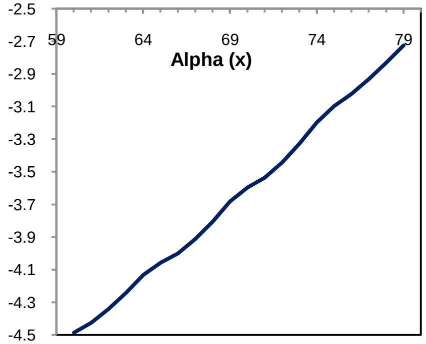
Males

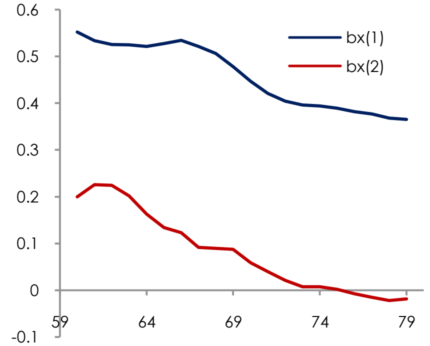


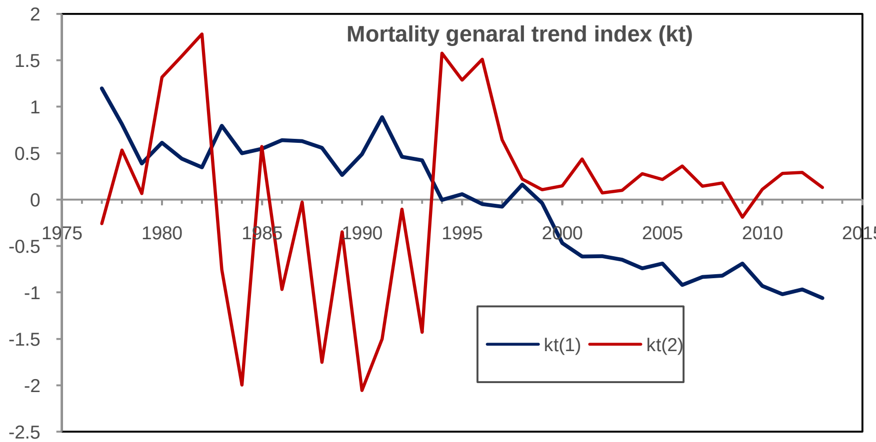




Females



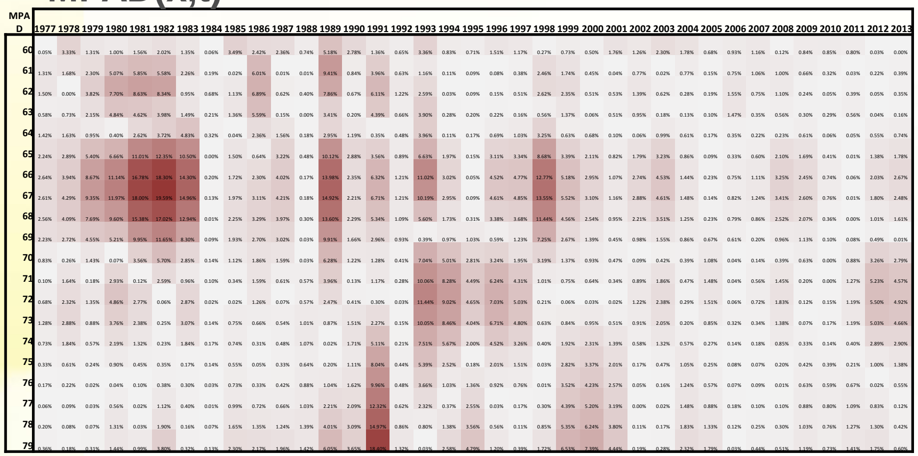




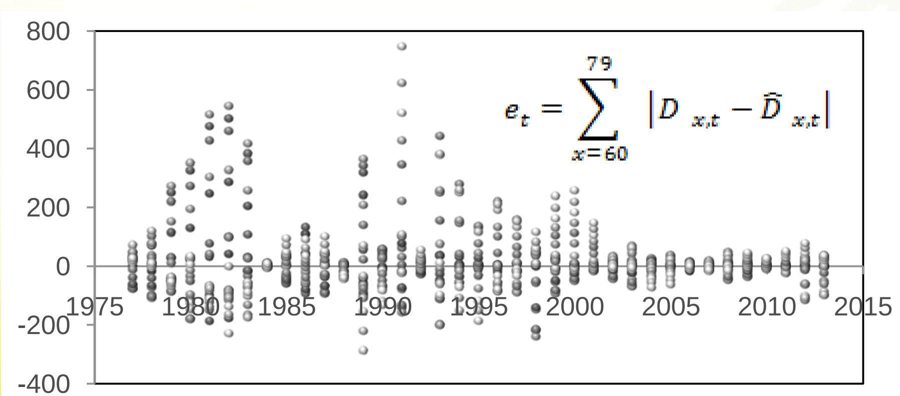
Errors distribution

Males

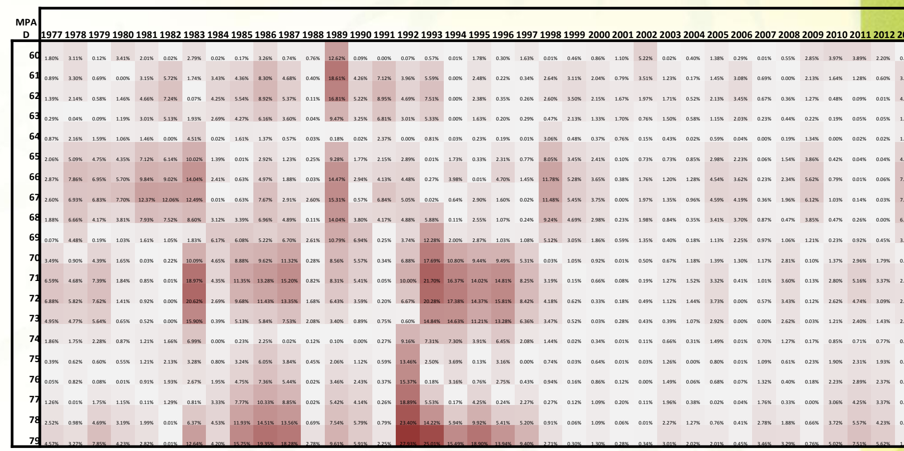
MPAD(x,t)



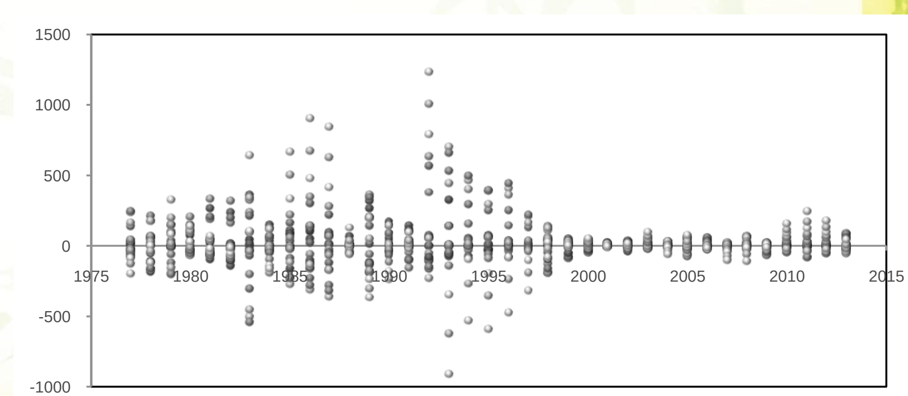
MPAD 2.18%



Females

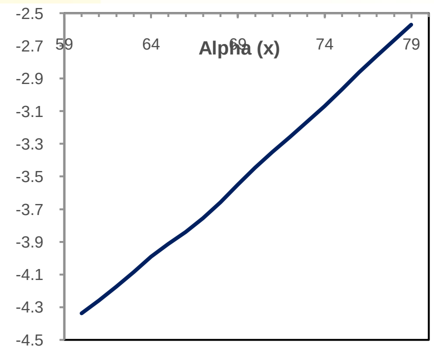


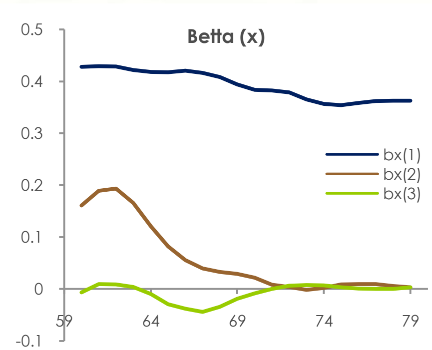
MPAD 3.32%

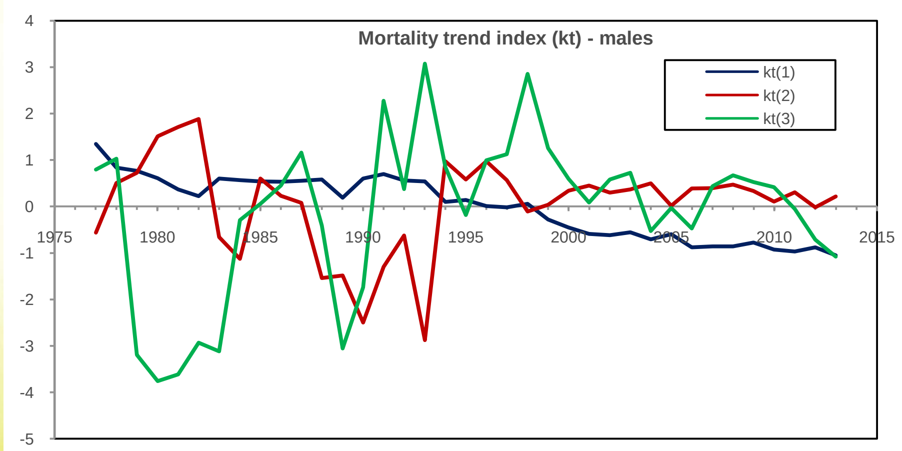


LC3 – estimation results

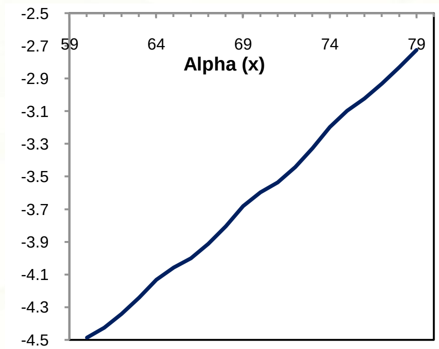
Males

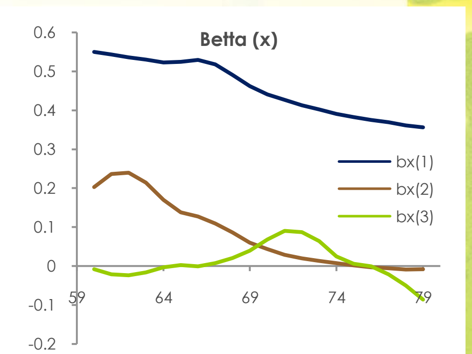


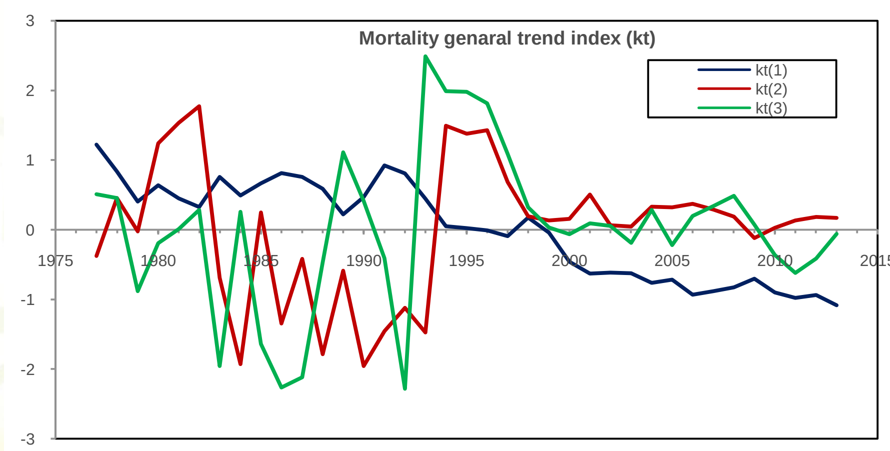




Females







Errors distribution

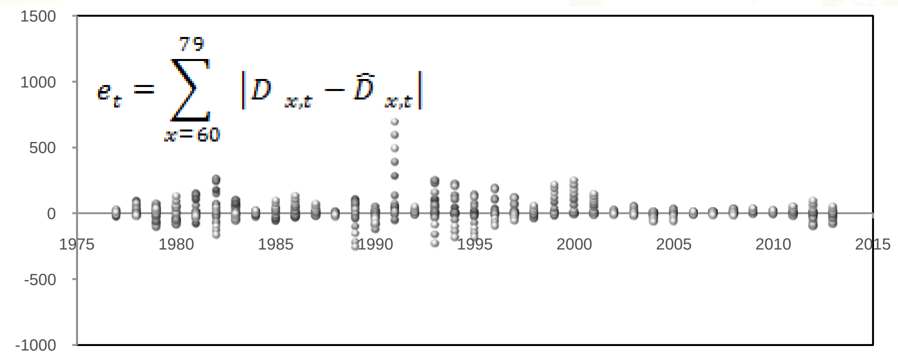
Males

MPAD(x,t)

MPAD	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
60	0.04%	3.59%	0.16%	0.60%	1.14%	2.52%	4.49%	0.18%	3.30%	0.49%	1.10%	0.74%	0.02%	2.95%	1.64%	0.17%	9.77%	0.19%	0.84%
61	1.37%	3.50%	0.21%	1.34%	2.30%	1.12%	4.41%	1.12%	3.21%	6.24%	3.69%	1.93%	6.82%	5.43%	2.42%	2.28%	0.14%	1.21%	0.66%
62	1.51%	1.83%	2.15%	4.22%	5.25%	3.93%	3.67%	0.62%	3.84%	6.50%	3.76%	1.59%	4.75%	5.05%	4.55%	2.35%	0.02%	1.56%	0.23%
63	0.64%	0.07%	1.74%	3.52%	3.48%	2.02%	0.57%	0.16%	3.06%	5.17%	2.79%	0.55%	0.22%	1.84%	3.78%	2.13%	0.16%	0.50%	0.60%
64	0.90%	1.41%	0.03%	0.10%	2.35%	4.21%	2.57%	0.17%	0.02%	0.71%	0.51%	0.05%	6.71%	1.81%	0.01%	0.04%	0.08%	0.01%	0.12%
65	1.73%	3.55%	1.92%	4.09%	8.98%	11.28%	6.73%	0.45%	4.56%	5.45%	5.39%	0.84%	14.83%	5.87%	4.12%	3.03%	0.05%	0.84%	1.55%
66	1.78%	5.74%	3.07%	5.94%	12.43%	14.91%	10.16%	1.43%	7.24%	8.94%	8.23%	2.06%	20.06%	8.80%	5.73%	4.26%	0.01%	2.27%	2.06%
67	1.71%	6.28%	3.69%	6.65%	13.58%	16.08%	11.05%	1.54%	7.70%	9.76%	8.61%	2.18%	20.68%	8.95%	6.13%	4.30%	0.17%	2.49%	2.16%
68	1.73%	5.71%	3.46%	5.64%	12.09%	14.46%	10.14%	1.22%	6.33%	8.02%	6.73%	1.89%	17.94%	7.55%	5.11%	2.94%	0.05%	2.15%	1.49%
69	1.43%	3.76%	2.82%	3.43%	8.38%	10.46%	7.65%	0.64%	3.09%	3.95%	2.76%	1.32%	12.00%	4.75%	2.88%	0.29%	0.28%	1.18%	0.35%
70	1.14%	1.55%	1.59%	0.03%	3.44%	5.67%	4.18%	0.00%	0.02%	0.20%	1.11%	0.68%	5.75%	1.84%	1.86%	2.29%	0.02%	0.94%	0.05%
71	0.61%	0.03%	0.72%	2.69%	0.04%	2.53%	1.82%	0.32%	1.74%	1.67%	3.27%	0.31%	2.13%	0.11%	1.65%	3.73%	0.07%	2.79%	0.42%
72	0.01%	0.66%	0.05%	4.31%	2.48%	0.05%	0.66%	0.16%	2.57%	2.78%	4.40%	0.47%	0.06%	0.32%	0.03%	4.61%	0.41%	2.98%	0.04%
73	0.69%	1.17%	0.05%	3.72%	2.50%	0.57%	0.07%	0.23%	2.66%	2.61%	4.23%	0.06%	1.10%	0.91%	1.96%	4.13%	0.06%	2.88%	0.04%
74	0.88%	0.76%	0.36%	2.30%	1.46%	0.35%	0.25%	0.13%	1.64%	1.26%	2.78%	0.24%	0.80%	0.62%	4.74%	2.67%	0.19%	1.77%	0.43%
75	0.92%	0.10%	0.54%	0.94%	0.35%	0.01%	0.00%	0.05%	0.61%	0.02%	1.39%	0.35%	0.13%	0.07%	7.35%	1.41%	0.13%	0.30%	1.06%
76	1.28%	0.08%	0.76%	0.17%	0.12%	0.03%	0.43%	0.04%	0.04%	0.88%	0.50%	0.69%	0.19%	0.10%	9.24%	0.42%	0.11%	0.07%	1.10%
77	1.61%	0.12%	1.12%	0.29%	0.05%	0.58%	1.01%	0.10%	0.24%	1.36%	0.02%	0.95%	0.80%	0.25%	11.57%	0.23%	0.01%	0.57%	1.38%
78	2.13%	0.46%	1.41%	0.77%	0.22%	1.51%	1.75%	0.18%	0.13%	1.46%	0.08%	1.24%	2.03%	0.68%	14.31%	0.63%	0.35%	0.95%	1.69%
79	2.40%	0.58%	2.33%	0.54%	1.46%	3.58%	2.88%	0.42%	0.11%	1.47%	0.11%	1.33%	3.51%	0.82%	17.71%	0.88%	0.06%	1.54%	2.24%

MPAD	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
60	0.13%	0.02%	0.16%	0.20%	0.18%	1.61%	0.93%	0.75%	1.82%	0.36%	1.60%	0.72%	0.03%	1.33%	1.39%	1.27%	0.02%	0.05%
61	1.85%	1.74%	2.40%	1.95%	1.01%	0.22%	0.75%	1.74%	0.83%	0.35%	0.39%	0.03%	0.56%	1.00%	0.28%	0.47%	0.89%	1.03%
62	2.39%	2.17%	2.64%	2.64%	1.12%	0.89%	1.49%	2.44%	0.25%	0.13%	1.04%	0.19%	0.87%	0.68%	0.12%	0.06%	0.70%	0.94%
63	1.15%	1.01%	0.71%	1.71%	0.44%	0.61%	1.06%	1.71%	0.01%	0.15%	1.03%	0.47%	0.30%	0.06%	0.00%	0.05%	0.21%	0.37%
64	0.00%	0.43%	2.73%	0.33%	0.66%	0.01%	0.09%	0.02%	0.50%	0.03%	0.04%	0.16%	0.21%	0.48%	0.05%	0.06%	0.51%	0.83%
65	1.54%	2.28%	7.51%	2.88%	2.23%	0.72%	1.16%	2.42%	1.26%	0.01%	1.27%	0.11%	1.02%	1.35%	0.02%	0.02%	1.75%	2.64%
66	3.31%	3.94%	11.10%	4.50%	3.39%	1.20%	1.97%	4.08%	1.73%	0.07%	1.74%	0.03%	1.85%	2.17%	0.14%	0.17%	2.75%	3.86%
67	3.74%	4.27%	11.83%	4.89%	3.63%	1.34%	2.12%	4.31%	1.79%	0.06%	1.78%	0.06%	1.97%	2.40%	0.21%	0.29%	2.60%	3.81%
68	3.41%	3.71%	10.08%	4.16%	3.06%	1.23%	1.67%	3.30%	1.46%	0.10%	1.48%	0.01%	1.53%	2.05%	0.07%	0.19%	1.72%	2.82%
69	2.34%	2.36%	6.53%	2.66%	1.91%	0.99%	0.92%	1.48%	0.72%	0.02%	0.74%	0.12%	0.91%	1.44%	0.03%	0.15%	0.05%	0.84%
70	0.38%	0.38%	3.08%	1.50%	1.12%	0.84%	0.19%	0.78%	0.48%	0.38%	0.31%	0.19%	0.21%	0.66%	0.22%	0.01%	2.08%	1.33%
71	1.21%	1.07%	1.16%	0.98%	0.80%	0.79%	0.93%	2.19%	0.52%	0.69%	0.16%	0.52%	1.03%	0.22%	0.35%	0.01%	3.63%	2.78%
72	1.45%	1.44%	0.05%	0.26%	0.18%	0.55%	1.13%	2.63%	0.21%	0.61%	0.04%	0.48%	1.16%	0.00%	0.42%	0.10%	3.89%	3.19%
73	1.57%	1.48%	0.49%	0.57%	0.72%	0.01%	0.90%	2.25%	0.21%	0.01%	0.22%	0.28%	0.90%	0.03%	0.12%	0.01%	3.45%	2.90%
74	0.98%	0.92%	0.58%	1.67%	1.92%	0.84%	0.50%	1.32%	0.65%	0.68%	0.16%	0.13%	0.51%	0.00%	0.00%	0.06%	1.99%	1.70%
75	0.06%	0.16%	0.47%	2.61%	2.94%	1.56%	0.14%	0.43%	1.03%	1.25%	0.05%	0.01%	0.13%	0.03%	0.02%	0.19%	0.59%	0.54%
76	0.01%	0.03%	0.68%	3.31%	3.67%	2.08%	0.03%	0.03%	1.26%	1.68%	0.01%	0.01%	0.05%	0.07%	0.12%	0.16%	0.02%	0.02%
77	0.12%	0.06%	1.14%	4.18%	4.53%	2.64%	0.14%	0.37%	1.55%	2.11%	0.02%	0.00%	0.02%	0.15%	0.20%	0.15%	0.48%	0.37%
78	0.11%	0.03%	1.85%	5.13%	5.45%	3.18%	0.30%	0.68%	1.97%	2.66%	0.14%	0.14%	0.17%	0.15%	0.45%	0.01%	0.71%	0.46%
79	0.18%	0.03%	2.85%	6.35%	6.59%	3.87%	0.30%	0.83%	2.38%	3.09%	0.20%	0.17%	0.18%	0.32%	0.51%	0.02%	1.09%	0.65%

MPAD 1.28%

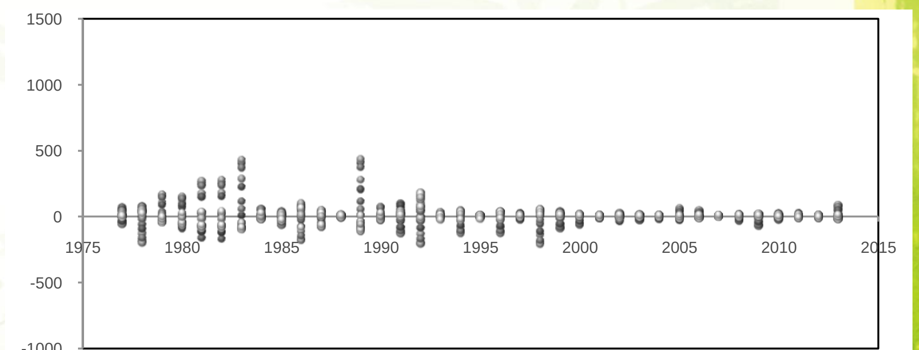


Females

MPAD	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
60	0.01%	3.74%	0.02%	3.11%	1.30%	1.03%	3.14%	0.01%	1.56%	0.04%	0.00%	0.07%	3.73%	0.02%	2.64%	0.30%	2.63%	0.00%	0.47%
61	2.50%	3.48%	1.89%	1.98%	5.57%	6.07%	5.30%	2.39%	1.09%	3.79%	2.02%	0.09%	6.92%	2.95%	4.12%	3.86%	0.59%	1.68%	0.03%
62	3.10%	2.15%	2.03%	4.11%	7.83%	8.35%	3.89%	2.42%	1.81%	4.44%	2.36%	0.16%	4.88%	3.05%	6.38%	4.56%	0.07%	1.58%	0.03%
63	1.98%	0.01%	0.70%	3.26%	5.58%	5.89%	0.01%	1.04%	1.33%	2.46%	1.47%	0.23%	0.38%	1.33%	4.77%	2.44%	0.04%	0.31%	0.16%
64	0.01%	2.43%	1.79%	0.01%	0.02%	0.01%	5.28%	0.59%	0.00%	1.33%	0.18%	0.00%	6.69%	0.75%	0.50%	1.67%	0.24%	1.76%	0.30%
65	1.42%	5.34%	5.27%	3.82%	6.38%	6.67%	11.85%	1.63%	1.46%	5.92%	1.95%	0.51%	14.07%	2.12%	3.89%	6.73%	0.63%	4.31%	0.02%
66	1.91%	7.90%	7.22%	5.11%	9.12%	9.59%	15.60%	2.99%	2.85%	8.99%	3.52%	0.24%	18.10%	3.72%	5.68%	10.23%	0.11%	6.25%	0.27%
67	2.08%	8.35%	7.48%	5.46%	9.82%	10.29%	16.16%	3.00%	2.84%	9.10%	3.49%	0.25%	19.13%	3.73%	6.00%	10.41%	0.07%	6.71%	0.10%
68	1.30%	6.61%	6.33%	4.94%	8.67%	9.02%	14.12%	2.48%	2.02%	6.97%	2.49%	0.10%	15.86%	3.08%	4.69%	8.10%	0.37%	5.47%	0.03%
69	1.16%	4.14%	4.07%	3.46%	5.90%	6.10%	9.62%	0.64%	0.58%	3.61%	0.83%	0.60%	9.38%	0.97%	3.32%	4.31%	0.80%	3.40%	0.25%
70	0.07%	1.59%	1.56%	1.15%	2.04%	2.04%	4.21%	0.38%	0.09%	0.94%	0.07%	0.01%	3.88%	0.54%	1.07%	2.01%	0.05%	1.48%	0.37%
71	0.72%	0.10%	0.06%	0.03%	0.05%	0.02%	0.19%	0.12%	0.00%	0.01%	0.05%	0.02%	0.72%	0.06%	0.04%	1.46%	0.27%	0.02%	0.02%
72	1.07%	0.74%	0.69%	1.01%	1.55%	1.64%	1.41%	0.01%	0.17%	1.49%	0.53%	0.47%	0.92%	0.00%	0.79%	0.43%	0.03%	0.45%	0.04%
73	0.54%	0.40%	0.84%	1.56%	2.17%	2.27%	1.16%	0.16%	0.29%	2.24%	1.02%	0.41%	1.50%	0.20%	0.64%	2.15%	0.17%	0.53%	0.08%
74	0.22%	0.06%	0.65%	1.24%	1.54%	1.54%	0.42%	0.15%	0.01%	1.53%	0.65%	0.11%	0.67%	0.14%	0.15%	2.59%	0.91%	0.86%	0.44%
75	0.00%	0.00%	0.52%	1.07%	1.35%	1.36%	0.25%	0.31%	0.14%	1.47%	0.75%	0.03%	0.85%	0.33%	0.03%	3.12%	0.56%	0.73%	0.29%
76	0.08%	0.24%	0.56%	1.21%	1.71%	1.79%	0.43%	0.38%	0.48%	1.95%	1.15%	0.06%	1.55%	0.43%	0.32%	3.87%	0.30%	0.66%	0.02%
77	0.01%	0.15%	0.49%	1.00%	1.36%	1.41%	0.47%	0.21%	0.19%	1.22%	0.65%	0.01%	1.10%	0.23%	0.21%	3.61%	0.43%	0.54%	0.00%
78	0.04%	0.11%	0.00%	0.02%	0.01%	0.00%	0.00%	0.03%	0.00%	0.01%	0.01%	0.12%	0.01%	0.03%	0.02%	3.01%	0.11%	0.01%	0.19%
79	0.06%	0.19%	0.48%	0.98%	1.42%	1.54%	0.25%	0.74%	0.76%	1.82%	1.30%	0.09%	1.88%	0.82%	0.06%	1.77%	0.78%	1.25%	0.82%

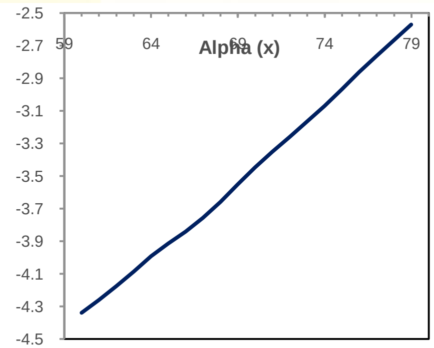
MPAD	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
60	0.00%	0.82%	0.04%	0.00%	0.08%	2.01%	4.86%	0.64%	0.55%	0.28%	0.02%	0.29%	0.30%	2.01%	3.32%	3.68%	1.79%	0.00%
61	2.04%	1.29%	2.77%	2.57%	1.60%	0.16%	2.39%	1.23%	0.84%	2.58%	1.76%	0.18%	1.66%	2.05%	1.80%	1.78%	0.94%	2.92%
62	2.06%	1.86%	2.73%	2.93%	1.69%	0.94%	0.81%	1.75%	1.21%	3.37%	2.12%	0.10%	2.15%	1.34%	0.68%	0.53%	0.29%	3.22%
63	0.74%	1.31%	0.43%	1.59%	0.72%	0.83%	0.02%	1.24%	0.86%	2.31%	1.27%	0.00%	1.50%	0.00%	0.02%	0.00%	0.06%	1.41%
64	1.56%	0.10%	3.45%	0.89%	0.97%	0.07%	0.31%	0.00%	0.00%	0.04%	0.40%	0.12%	0.05%	1.73%	0.37%	0.01%	0.20%	1.67%
65	4.41%	0.89%	8.59%	3.78%	3.12%	0.72%	0.91%	1.48%	1.05%	2.67%	2.28%	0.18%	1.80%	4.40%	1.24%	0.46%	0.70%	5.10%
66	6.53%	1.27%	12.25%	5.59%	4.50%	1.07%	1.81%	2.23%	1.54%	4.13%	3.51%	0.41%	2.67%	6.23%	2.04%	1.11%	1.21%	7.31%
67	7.03%	1.47%	12.61%	5.88%	4.65%	1.12%	1.95%	2.33%	1.61%	4.33%	3.62%	0.42%	2.78%	6.29%	2.12%	1.19%	1.25%	7.47%
68	5.77%	1.33%	10.12%	4.92%	4.01%	1.20%	1.28%	2.20%	1.62%	3.20%	2.52%	0.01%	2.54%	5.25%	2.08%	1.38%	1.40%	5.64%
69	3.56%	0.98%	6.09%	3.01%	2.35%	0.55%	0.67%	1.24%	0.89%	2.02%	1.50%	0.00%	1.50%	3.04%	1.00%	0.46%	0.55%	3.46%
70	1.52%	0.35%	2.26%	1.16%	0.91%	0.09%	0.15%	0.48%	0.24%	0.67%	0.44%	0.02%	0.49%	1.08%	0.37%	0.18%	0.20%	1.21%
71	0.01%	0.31%	0.01%	0.01%	0.00%	0.41%	0.00%	0.01%	0.29%	0.08%	0.03%	0.17%	0.15%	0.02%	0.03%	0.04%	0.04%	0.03%
72	0.44%	0.32%	0.88%	0.43%	0.30%	0.34%	0.21%	0.15%	0.26%	0.37%	0.42%	0.02%	0.20%	0.39%	0.13%	0.08%	0.10%	0.69%
73	0.47%	0.10%	0.74%	0.33%	0.33%	0.24%	0.21%	0.24%	0.20%	0.33%	0.42%	0.04%	0.18%	0.50%	0.40%	0.45%	0.35%	0.57%
74	0.70%	0.12%	0.18%	0.01%	0.04%	0.00%	0.22%	0.01%	0.00%	0.28%	0.32%	0.09%	0.03%	0.19%	0.22%	0.29%	0.17%	0.32%
75	0.60%	0.03%	0.11%	0.01%	0.07%	0.01%	0.18%	0.04%	0.01%	0.20%	0.26%	0.08%	0.02%	0.18%	0.28%	0.38%	0.24%	0.23%
76	0.56%	0.05%	0.41%	0.18%	0.18%	0.00%	0.25%	0.09%	0.04%	0.30%	0.41%	0.17%	0.03%	0.26%	0.31%	0.40%	0.25%	0.47%
77	0.47%	0.02%	0.29%	0.16%	0.17%	0.02%	0.12%	0.08%	0.02%	0.19%	0.23%	0.04%	0.08%	0.26%	0.28%	0.32%	0.21%	0.26%
78	0.04%	0.04%	0.08%	0.05%	0.01%	0.03%	0.00%	0.07%	0.05%	0.03%	0.03%	0.00%	0.01%	0.01%	0.04%	0.00%	0.02%	0.01%
79	1.00%	0.04%	0.63%	0.06%	0.09%	0.01%	0.37%	0.09%	0.06%	0.32%	0.46%	0.30%	0.14%	0.11%	0.07%	0.27%	0.16%	0.65%

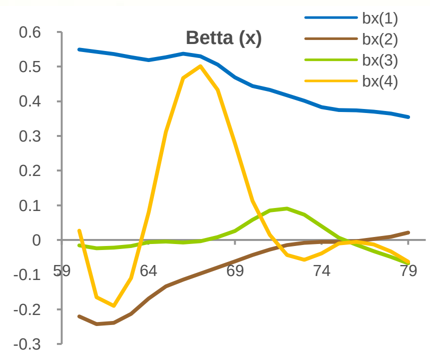
MPAD 1.69%

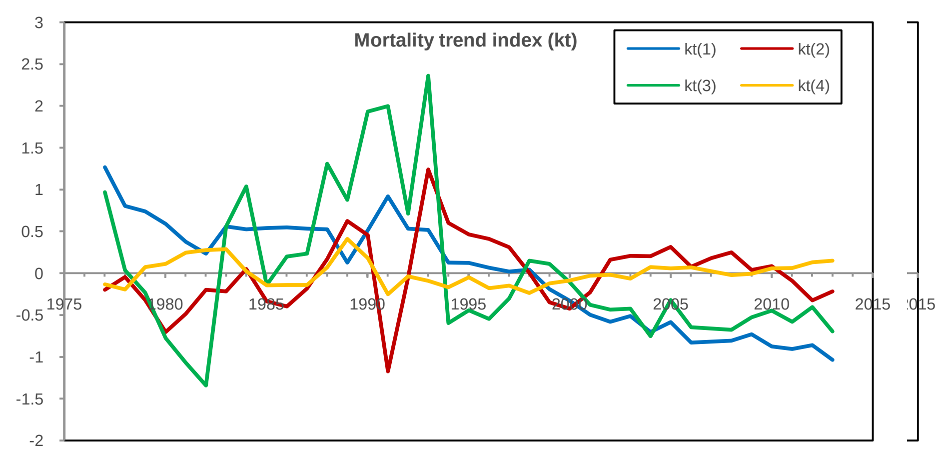


LC4 – estimation results

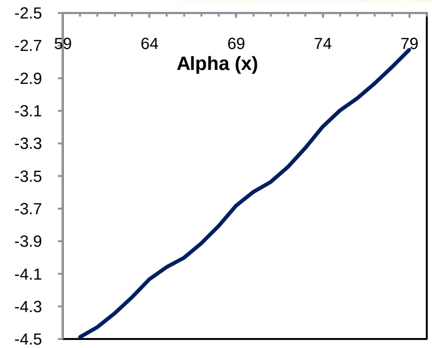
Males

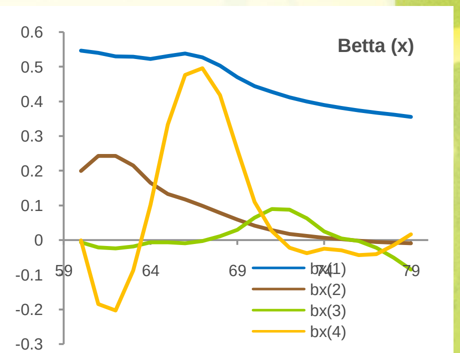


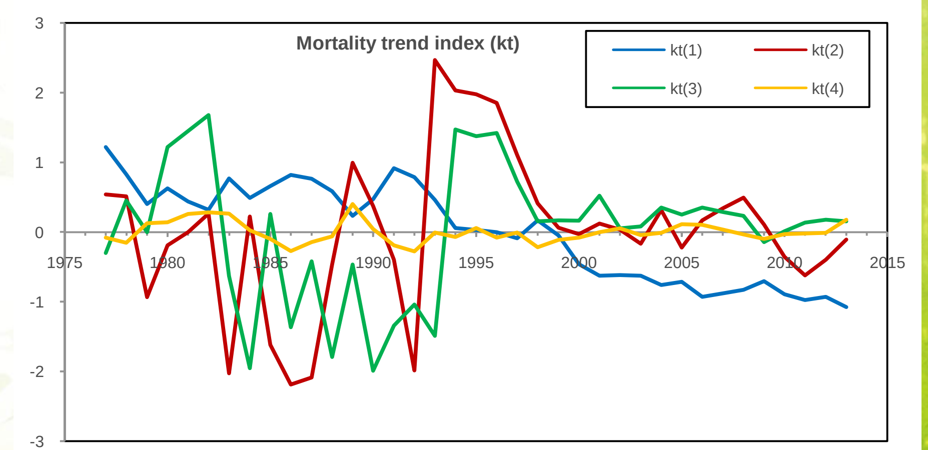




Females







Errors distribution

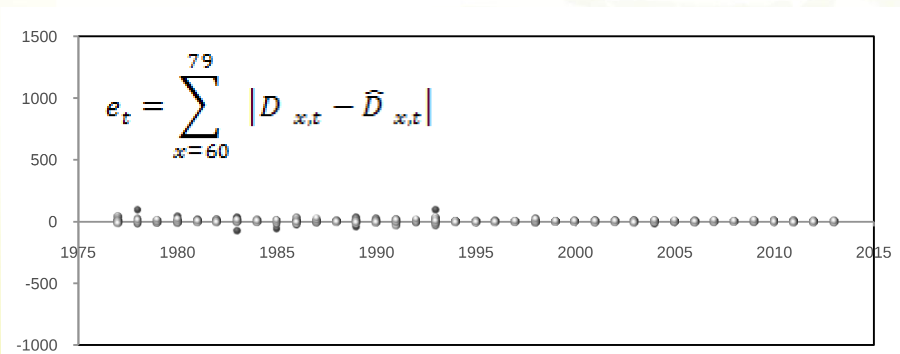
Males

MPAD(x,t)

MPAD	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
60	0,00%	4,43%	0,30%	1,86%	0,53%	0,00%	5,21%	0,01%	3,68%	1,90%	1,12%	0,69%	4,29%	2,32%	0,76%	0,65%	8,70%	0,10%	0,98%
61	0,10%	1,23%	0,04%	0,64%	0,38%	0,35%	0,73%	0,07%	1,49%	0,91%	0,40%	0,23%	0,86%	0,00%	0,00%	0,00%	2,52%	0,14%	0,15%
62	0,11%	0,24%	0,32%	0,05%	0,08%	0,02%	1,15%	0,00%	0,01%	0,07%	0,16%	0,13%	0,67%	1,10%	1,09%	0,27%	1,10%	0,08%	0,12%
63	0,29%	0,78%	0,57%	0,30%	0,19%	0,00%	1,75%	0,03%	0,35%	0,00%	0,12%	0,01%	2,19%	0,00%	0,83%	0,11%	1,18%	0,01%	0,12%
64	0,73%	0,13%	0,63%	0,05%	0,08%	0,00%	0,52%	0,31%	0,22%	0,05%	0,01%	0,16%	1,34%	0,59%	0,40%	0,29%	0,01%	0,21%	0,06%
65	0,56%	0,37%	0,41%	0,21%	0,03%	0,00%	0,00%	0,17%	0,02%	0,09%	0,01%	0,01%	0,57%	0,75%	0,13%	0,25%	0,16%	0,14%	0,10%
66	0,14%	0,29%	0,24%	0,03%	0,08%	0,10%	0,04%	0,00%	0,21%	0,12%	0,25%	0,02%	0,06%	0,34%	0,13%	0,00%	0,49%	0,11%	0,10%
67	0,01%	0,00%	0,17%	0,07%	0,01%	0,02%	0,09%	0,10%	0,07%	0,08%	0,21%	0,07%	0,20%	0,16%	0,06%	0,08%	0,00%	0,01%	0,13%
68	0,00%	0,24%	0,08%	0,07%	0,37%	0,37%	0,22%	0,07%	0,11%	0,03%	0,04%	0,00%	0,31%	0,02%	0,05%	0,01%	0,52%	0,06%	0,02%
69	0,07%	0,30%	0,06%	0,21%	0,64%	0,68%	0,26%	0,05%	0,24%	0,04%	0,13%	0,03%	0,16%	0,00%	0,00%	0,13%	0,99%	0,00%	0,06%
70	0,04%	0,29%	0,25%	0,00%	0,44%	0,58%	0,00%	0,12%	0,21%	0,30%	0,23%	0,00%	0,08%	0,03%	0,11%	0,19%	0,68%	0,03%	0,05%
71	0,70%	0,06%	0,25%	0,35%	0,01%	0,23%	0,03%	0,39%	0,01%	0,73%	0,09%	0,20%	0,00%	0,00%	0,54%	0,00%	0,07%	0,00%	0,01%
72	1,03%	0,15%	0,10%	0,35%	0,04%	0,23%	0,00%	0,39%	0,16%	0,87%	0,02%	0,14%	0,00%	0,22%	0,38%	0,04%	0,87%	0,01%	0,08%
73	1,06%	0,28%	0,17%	0,53%	0,28%	0,01%	0,11%	0,37%	0,10%	0,70%	0,01%	0,12%	0,00%	0,20%	0,00%	0,07%	0,47%	0,15%	0,15%
74	0,71%	0,27%	0,05%	0,22%	0,00%	0,17%	0,00%	0,22%	0,01%	0,35%	0,02%	0,00%	0,06%	0,24%	0,41%	0,06%	0,00%	0,10%	0,07%
75	0,36%	0,22%	0,04%	0,15%	0,00%	0,09%	0,03%	0,14%	0,18%	0,02%	0,03%	0,03%	0,06%	0,12%	0,68%	0,09%	0,73%	0,08%	0,00%
76	0,32%	0,25%	0,04%	0,08%	0,00%	0,04%	0,12%	0,13%	0,25%	0,21%	0,07%	0,02%	0,03%	0,05%	0,78%	0,14%	0,99%	0,01%	0,07%
77	0,16%	0,27%	0,09%	0,03%	0,00%	0,03%	0,13%	0,07%	0,27%	0,34%	0,13%	0,10%	0,11%	0,15%	0,88%	0,17%	0,95%	0,03%	0,10%
78	0,04%	0,27%	0,16%	0,22%	0,00%	0,20%	0,27%	0,11%	0,19%	0,34%	0,27%	0,09%	0,21%	0,19%	0,45%	0,31%	0,75%	0,26%	0,27%
79	0,23%	0,34%	0,21%	0,48%	0,00%	0,37%	0,30%	0,10%	0,00%	0,25%	0,51%	0,19%	0,46%	0,46%	0,00%	0,46%	0,31%	0,34%	0,32%

MPAD	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
60	0,24%	0,06%	1,91%	0,03%	0,70%	1,15%	1,04%	0,93%	2,04%	0,68%	1,19%	0,67%	0,01%	1,24%	0,79%	0,80%	0,65%	0,83%
61	0,20%	0,00%	0,26%	0,03%	0,04%	0,17%	0,02%	0,01%	0,21%	0,11%	0,01%	0,12%	0,03%	0,18%	0,07%	0,01%	0,24%	0,24%
62	0,00%	0,06%	0,24%	0,24%	0,00%	0,45%	0,51%	0,47%	0,52%	0,30%	0,67%	0,23%	0,00%	0,33%	0,36%	0,39%	0,01%	0,00%
63	0,09%	0,02%	0,55%	0,05%	0,23%	0,41%	0,46%	0,41%	0,60%	0,26%	0,85%	0,39%	0,10%	0,55%	0,51%	0,55%	0,00%	0,00%
64	0,31%	0,08%	0,09%	0,12%	0,00%	0,28%	0,25%	0,24%	0,24%	0,02%	0,46%	0,18%	0,00%	0,21%	0,29%	0,26%	0,01%	0,04%
65	0,19%	0,04%	0,07%	0,04%	0,05%	0,10%	0,02%	0,03%	0,01%	0,09%	0,06%	0,01%	0,01%	0,03%	0,12%	0,03%	0,04%	0,00%
66	0,12%	0,06%	0,03%	0,01%	0,04%	0,10%	0,04%	0,06%	0,12%	0,03%	0,04%	0,07%	0,00%	0,04%	0,12%	0,01%	0,05%	0,03%
67	0,02%	0,03%	0,04%	0,04%	0,13%	0,03%	0,10%	0,00%	0,13%	0,09%	0,07%	0,13%	0,09%	0,08%	0,01%	0,00%	0,04%	0,05%
68	0,08%	0,00%	0,08%	0,00%	0,13%	0,04%	0,14%	0,09%	0,02%	0,10%	0,01%	0,10%	0,17%	0,09%	0,06%	0,02%	0,19%	0,22%
69	0,03%	0,00%	0,14%	0,03%	0,12%	0,13%	0,13%	0,14%	0,12%	0,08%	0,14%	0,00%	0,16%	0,05%	0,08%	0,07%	0,35%	0,40%
70	0,00%	0,03%	0,06%	0,00%	0,09%	0,13%	0,19%	0,23%	0,01%	0,19%	0,04%	0,01%	0,20%	0,09%	0,27%	0,13%	0,25%	0,27%
71	0,04%	0,10%	0,30%	0,05%	0,10%	0,18%	0,13%	0,16%	0,00%	0,16%	0,05%	0,10%	0,07%	0,00%	0,29%	0,19%	0,22%	0,22%
72	0,07%	0,17%	0,53%	0,10%	0,05%	0,12%	0,07%	0,03%	0,06%	0,11%	0,00%	0,13%	0,03%	0,01%	0,29%	0,28%	0,00%	0,03%
73	0,00%	0,12%	0,47%	0,09%	0,00%	0,07%	0,04%	0,04%	0,06%	0,10%	0,01%	0,11%	0,04%	0,02%	0,26%	0,25%	0,13%	0,17%
74	0,06%	0,12%	0,31%	0,02%	0,10%	0,01%	0,02%	0,17%	0,02%	0,03%	0,08%	0,11%	0,08%	0,05%	0,15%	0,11%	0,22%	0,24%
75	0,07%	0,05%	0,03%	0,05%	0,12%	0,03%	0,00%	0,18%	0,08%	0,07%	0,14%	0,04%	0,01%	0,12%	0,09%	0,07%	0,11%	0,12%
76	0,13%	0,06%	0,05%	0,00%	0,05%	0,01%	0,01%	0,23%	0,08%	0,09%	0,16%	0,00%	0,03%	0,13%	0,06%	0,17%	0,02%	0,08%
77	0,14%	0,03%	0,13%	0,03%	0,00%	0,01%	0,03%	0,23%	0,00%	0,17%	0,13%	0,10%	0,13%	0,19%	0,06%	0,24%	0,04%	0,07%
78	0,29%	0,08%	0,19%	0,02%	0,00%	0,01%	0,00%	0,32%	0,02%	0,17%	0,15%	0,12%	0,11%	0,19%	0,00%	0,35%	0,08%	0,07%
79	0,28%	0,01%	0,29%	0,06%	0,04%	0,01%	0,00%	0,37%	0,14%	0,22%	0,15%	0,16%	0,13%	0,19%	0,10%	0,51%	0,22%	0,01%

MPAD	0,25%

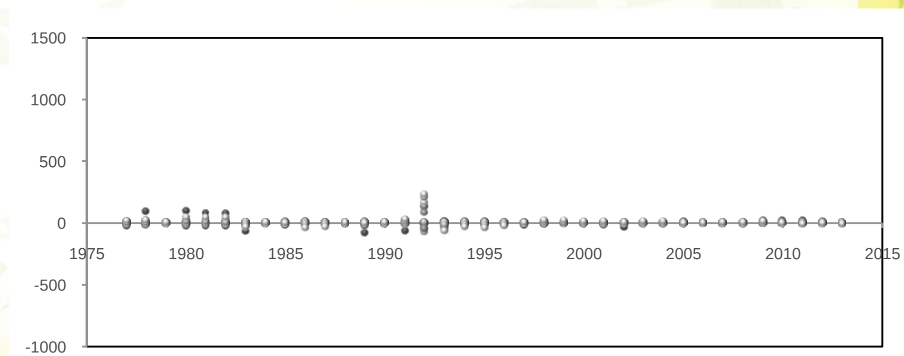


Females

MPAD	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
60	1.30%	4.50%	0.01%	4.70%	4.07%	3.93%	4.66%	0.07%	1.07%	0.14%	0.28%	0.09%	7.25%	0.11%	4.72%	0.12%	1.30%	0.12%	0.71%
61	0.12%	1.20%	0.13%	1.10%	1.07%	1.03%	1.86%	0.06%	0.82%	0.02%	0.26%	0.22%	2.60%	0.01%	0.55%	0.27%	1.00%	0.29%	0.02%
62	0.64%	0.04%	0.36%	0.15%	0.00%	0.01%	0.09%	0.34%	0.09%	0.14%	0.04%	0.05%	0.05%	0.46%	1.39%	0.01%	0.01%	0.11%	0.44%
63	0.01%	0.69%	0.09%	1.05%	0.97%	0.91%	0.14%	0.00%	0.18%	0.01%	0.12%	0.00%	0.78%	0.01%	1.30%	0.04%	0.01%	0.01%	0.24%
64	0.46%	0.11%	0.00%	0.03%	0.05%	0.00%	0.23%	0.02%	0.51%	0.04%	0.20%	0.21%	0.34%	0.07%	0.10%	0.00%	0.23%	0.11%	0.02%
65	0.31%	0.32%	0.01%	0.13%	0.00%	0.02%	0.04%	0.19%	0.06%	0.01%	0.09%	0.02%	0.12%	0.21%	0.28%	0.04%	0.04%	0.12%	0.06%
66	0.01%	0.18%	0.17%	0.01%	0.12%	0.09%	0.01%	0.05%	0.04%	0.01%	0.11%	0.04%	0.28%	0.01%	0.09%	0.10%	0.30%	0.05%	0.12%
67	0.07%	0.00%	0.12%	0.01%	0.03%	0.00%	0.00%	0.04%	0.05%	0.06%	0.01%	0.00%	0.00%	0.10%	0.00%	0.02%	0.04%	0.02%	0.14%
68	0.00%	0.05%	0.03%	0.02%	0.09%	0.11%	0.07%	0.18%	0.03%	0.01%	0.01%	0.09%	0.51%	0.23%	0.05%	0.06%	0.33%	0.01%	0.02%
69	0.08%	0.08%	0.17%	0.00%	0.12%	0.15%	0.08%	0.00%	0.10%	0.00%	0.12%	0.03%	0.55%	0.00%	0.04%	0.25%	0.64%	0.01%	0.07%
70	0.00%	0.00%	0.05%	0.12%	0.18%	0.18%	0.03%	0.09%	0.14%	0.20%	0.06%	0.00%	0.38%	0.12%	0.00%	1.53%	0.01%	0.33%	0.30%
71	0.36%	0.24%	0.12%	0.10%	0.08%	0.10%	0.69%	0.21%	0.04%	0.56%	0.36%	0.09%	0.02%	0.25%	0.14%	2.87%	0.64%	0.42%	0.25%
72	0.40%	0.27%	0.18%	0.07%	0.00%	0.06%	0.68%	0.00%	0.17%	0.17%	0.09%	0.00%	0.06%	0.02%	0.04%	1.94%	1.06%	0.26%	0.03%
73	0.19%	0.01%	0.03%	0.30%	0.33%	0.24%	0.29%	0.06%	0.00%	0.21%	0.06%	0.01%	0.23%	0.10%	0.11%	0.04%	0.32%	0.07%	0.28%
74	0.05%	0.09%	0.08%	0.26%	0.23%	0.14%	0.02%	0.15%	0.01%	0.33%	0.15%	0.18%	0.03%	0.13%	0.28%	2.07%	0.06%	0.39%	0.46%
75	0.02%	0.06%	0.05%	0.19%	0.17%	0.10%	0.13%	0.07%	0.01%	0.30%	0.14%	0.11%	0.06%	0.05%	0.19%	3.04%	0.16%	0.34%	0.38%
76	0.01%	0.04%	0.06%	0.29%	0.34%	0.31%	0.11%	0.02%	0.01%	0.29%	0.14%	0.07%	0.03%	0.00%	0.13%	3.43%	0.19%	0.30%	0.29%
77	0.03%	0.05%	0.02%	0.00%	0.02%	0.00%	0.10%	0.01%	0.01%	0.01%	0.00%	0.09%	0.06%	0.00%	0.08%	4.04%	0.01%	0.13%	0.11%
78	0.22%	0.34%	0.01%	0.38%	0.33%	0.30%	0.27%	0.17%	0.00%	0.21%	0.22%	0.09%	0.16%	0.15%	0.31%	4.95%	0.50%	0.34%	0.46%
79	0.51%	0.78%	0.12%	1.12%	1.35%	1.33%	0.77%	0.24%	0.00%	0.84%	0.67%	0.17%	0.15%	0.18%	0.64%	5.59%	2.06%	1.12%	1.28%

MPAD	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
60	0.01%	1.71%	1.22%	0.37%	0.03%	2.37%	4.77%	1.23%	1.09%	1.42%	0.15%	0.59%	1.37%	2.50%	3.33%	3.29%	1.71%	0.20%
61	0.25%	0.22%	0.31%	0.07%	0.01%	0.67%	1.25%	0.23%	0.09%	0.69%	0.16%	0.06%	0.20%	1.09%	1.33%	0.86%	0.52%	0.12%
62	0.00%	0.50%	0.00%	0.12%	0.16%	0.06%	0.22%	0.04%	0.11%	0.00%	0.20%	0.01%	0.01%	0.07%	0.12%	0.69%	0.38%	0.17%
63	0.18%	0.48%	0.00%	0.20%	0.03%	0.45%	0.71%	0.34%	0.39%	0.08%	0.05%	0.23%	0.38%	0.04%	0.14%	0.59%	0.20%	0.08%
64	0.23%	0.02%	0.01%	0.03%	0.05%	0.12%	0.04%	0.05%	0.06%	0.01%	0.11%	0.04%	0.01%	0.04%	0.02%	0.14%	0.04%	0.01%
65	0.16%	0.13%	0.02%	0.02%	0.04%	0.12%	0.27%	0.10%	0.10%	0.13%	0.01%	0.10%	0.17%	0.05%	0.15%	0.14%	0.07%	0.01%
66	0.05%	0.02%	0.21%	0.01%	0.04%	0.00%	0.00%	0.06%	0.07%	0.23%	0.10%	0.05%	0.19%	0.21%	0.05%	0.02%	0.01%	0.10%
67	0.04%	0.06%	0.23%	0.01%	0.01%	0.04%	0.09%	0.00%	0.00%	0.13%	0.11%	0.02%	0.02%	0.08%	0.08%	0.02%	0.00%	0.03%
68	0.03%	0.01%	0.00%	0.03%	0.06%	0.00%	0.00%	0.04%	0.04%	0.11%	0.03%	0.02%	0.18%	0.23%	0.00%	0.01%	0.02%	0.22%
69	0.03%	0.10%	0.10%	0.01%	0.03%	0.08%	0.09%	0.01%	0.02%	0.27%	0.13%	0.00%	0.25%	0.39%	0.05%	0.01%	0.00%	0.32%
70	0.29%	0.13%	0.07%	0.03%	0.01%	0.01%	0.00%	0.00%	0.02%	0.14%	0.00%	0.03%	0.21%	0.29%	0.05%	0.00%	0.00%	0.16%
71	0.33%	0.04%	0.14%	0.17%	0.06%	0.16%	0.16%	0.03%	0.09%	0.01%	0.16%	0.11%	0.23%	0.20%	0.00%	0.07%	0.02%	0.03%
72	0.22%	0.04%	0.00%	0.12%	0.00%	0.14%	0.14%	0.00%	0.01%	0.04%	0.14%	0.02%	0.05%	0.00%	0.02%	0.00%	0.00%	0.01%
73	0.00%	0.00%	0.22%	0.08%	0.12%	0.01%	0.06%	0.06%	0.10%	0.01%	0.08%	0.05%	0.06%	0.08%	0.01%	0.06%	0.00%	0.08%
74	0.26%	0.02%	0.24%	0.15%	0.11%	0.06%	0.03%	0.04%	0.09%	0.03%	0.00%	0.07%	0.07%	0.04%	0.04%	0.13%	0.05%	0.04%
75	0.22%	0.03%	0.21%	0.13%	0.10%	0.09%	0.06%	0.04%	0.10%	0.04%	0.05%	0.10%	0.11%	0.05%	0.00%	0.06%	0.01%	0.00%
76	0.19%	0.02%	0.16%	0.08%	0.05%	0.05%	0.02%	0.01%	0.06%	0.01%	0.01%	0.06%	0.08%	0.03%	0.02%	0.07%	0.03%	0.03%
77	0.07%	0.00%	0.08%	0.00%	0.01%	0.00%	0.01%	0.03%	0.00%	0.02%	0.00%	0.02%	0.05%	0.00%	0.01%	0.00%	0.01%	0.03%
78	0.27%	0.00%	0.29%	0.26%	0.22%	0.09%	0.00%	0.15%	0.13%	0.04%	0.05%	0.04%	0.08%	0.22%	0.01%	0.10%	0.00%	0.14%
79	0.89%	0.04%	0.68%	0.61%	0.49%	0.31%	0.09%	0.11%	0.35%	0.00%	0.02%	0.19%	0.25%	0.44%	0.02%	0.24%	0.01%	0.23%

MPAD	0,29%



Mortality trend index projection

- Lee-Carter (1992) noted that the model would not fit the age-specific mortality data exactly in the jump-off year, they noted that it would be possible to set x equal to the most recently observed log age specific-rates,

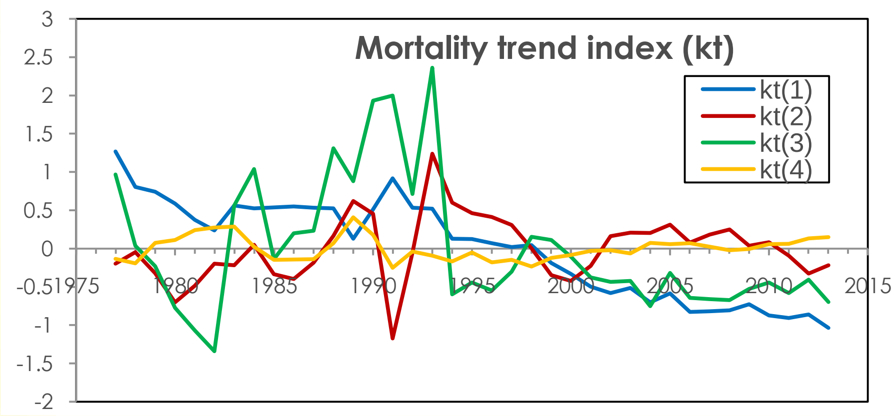
- Bell (1997) assessed the performance of several mortality forecasts: LC (as published); LC (with the jump-off year corrected);

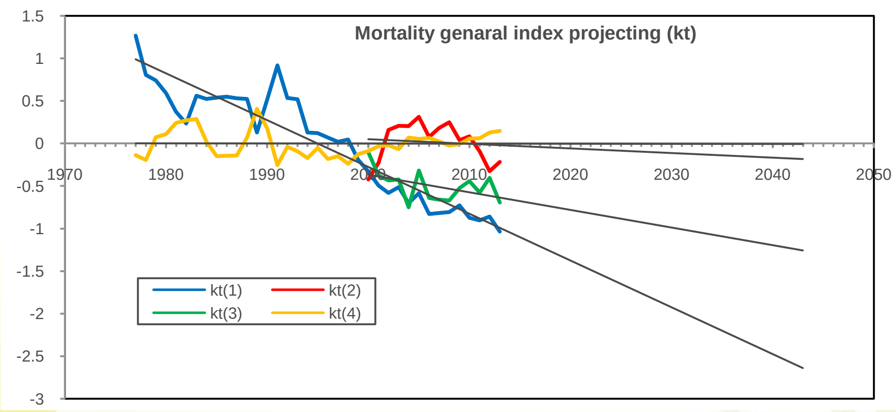
- For the Case of the algerian mortality Data, the Black decade (1990-1999) has marked a heigh mortality level wich may greatly affect the general mortality trend

- The extra time components which marque some irregularities during the Black decade, it's only the range [1998 – 2013] that will be considered for the projection

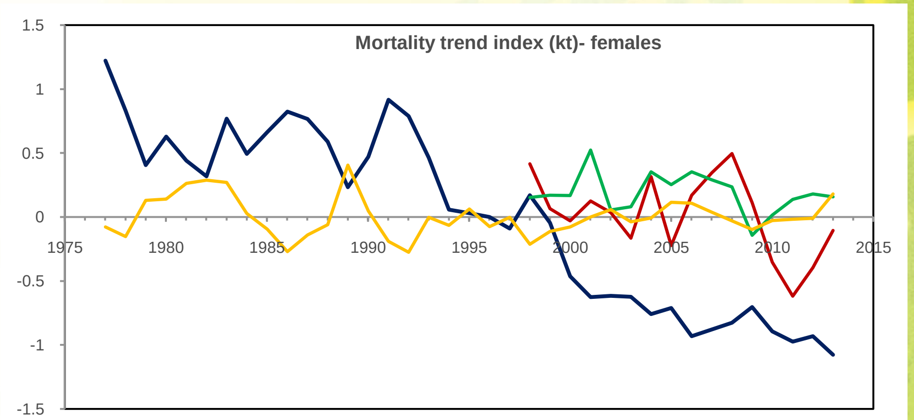
Mortality trend index - projecting

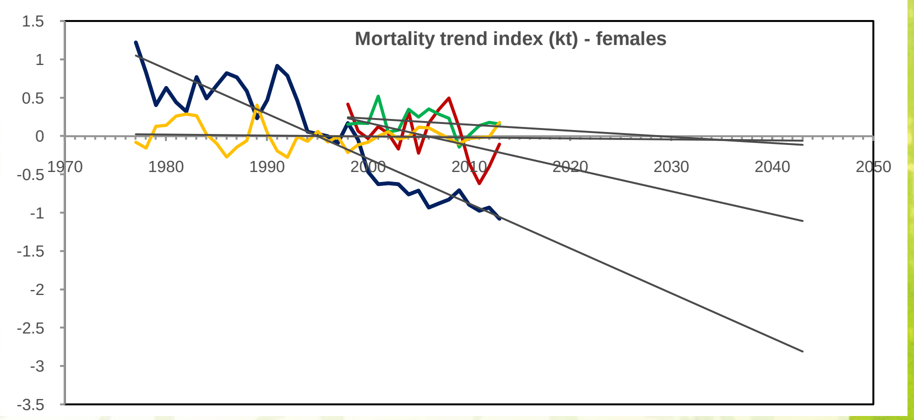
Males





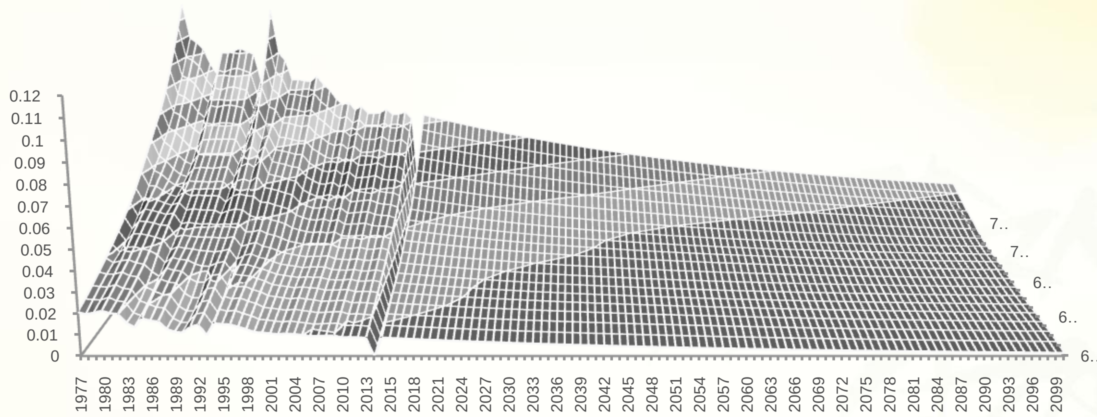
Females



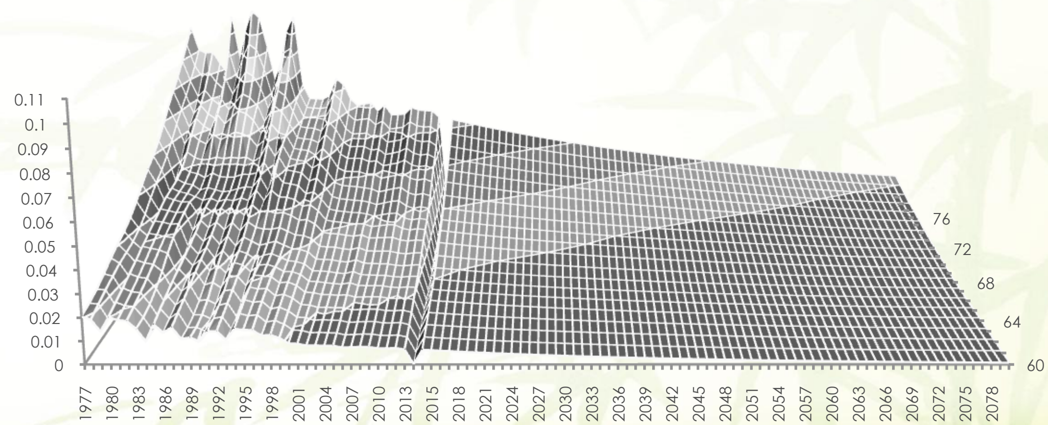


Projected mortality surface

Males

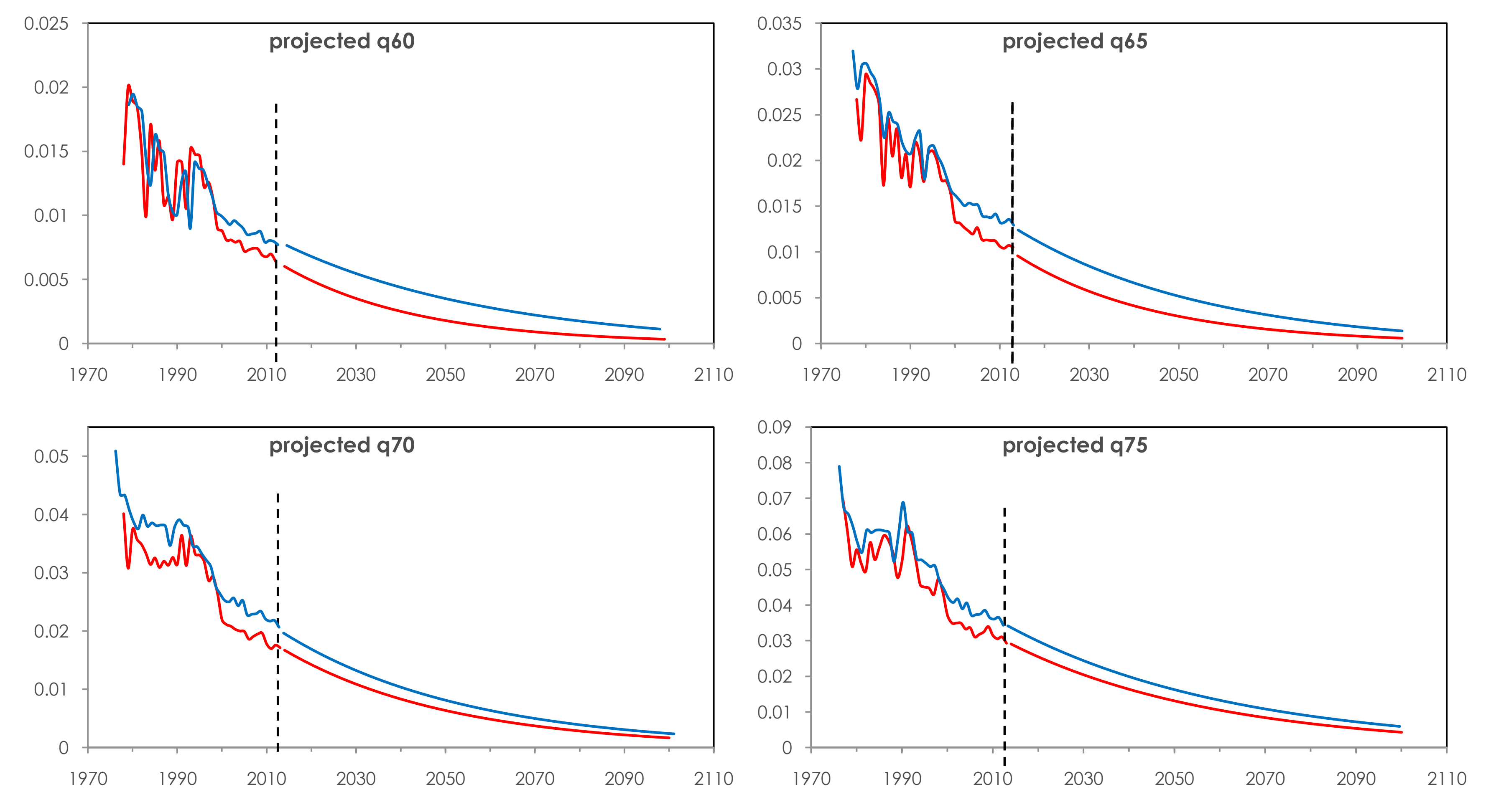


Projected mortality surface (qx)



Females

Projected mortality rates



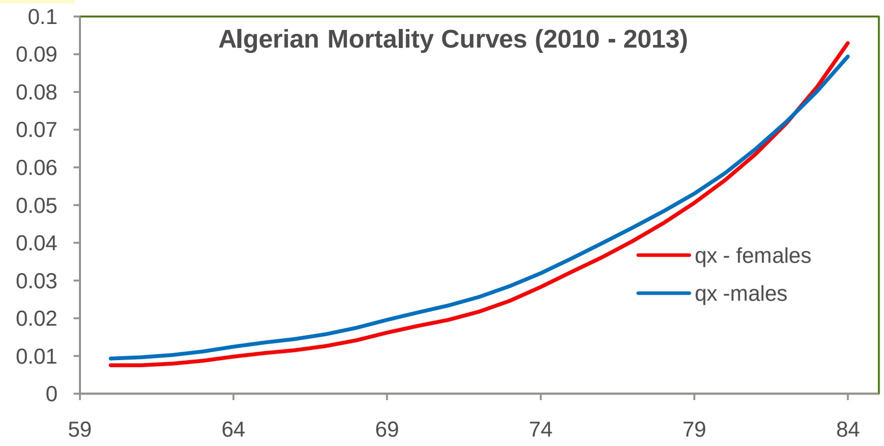
Old Ages Mortality

- Mortality trend changes beyond the age of 80 or 85 (Coale & Guo, 1989) : Specific models were proposed for old ages mortality.
- For developing countries, mortality data at the older ages are unavailable or unreliable
- Several Modal life tables were proposed in this issue, its are used to complete the missing data:
- for the old age mortality, several model are proposed : **Coale & Guo (1989); Coale & Kisker (1990), Kannisto (1994) Denuit & Gourniaux (2005)**
- All the models which were proposed in this way, have been verified and adjusted on the available data at the older ages
- This data concerns some of the developped countries
- these models, as initially proposed, don't guarantee the quality of the estimated results for the case of the developping countries : Algeria
- Propose a specific (modified) model for the old ages mortality for the algerian population

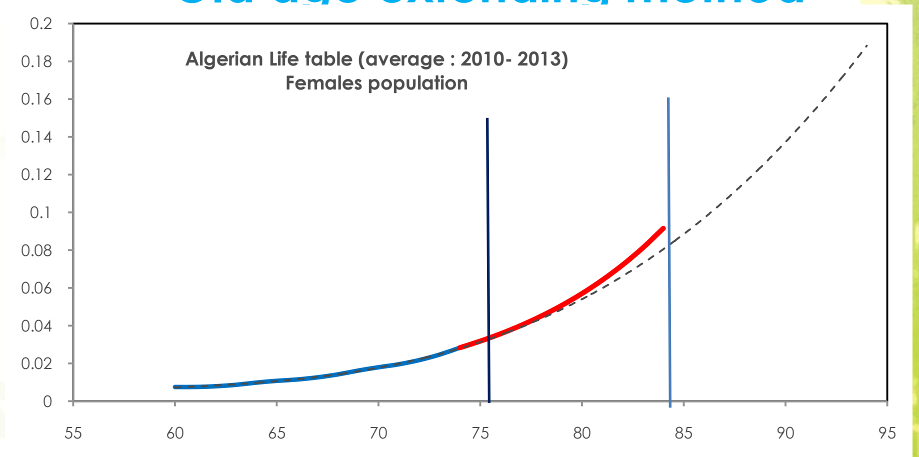
Old ages mortality Models

- It's only starting from 2010, that the algerian life tables were extended untel the age groupe [80 -85[years;
- No mortality data beyond the age of 85
- To use this data to predict the mortality trend at the old ages

Mortality curves



Old age extending method



Use the age range [60 – 75 [to adjust the parameters of old ages mortality model

Use the age range [75 – 84[to evaluate and orient the parametrisation of the old age mortality model.

Old ages mortality Models

Extrapolation Formula (Coale & Kisker, 1990)

$$\hat{u}_x = \hat{u}_{x-1}\exp\big(k_{80} + s.(x-80)\big) \quad x = 80,81,\ldots,109.$$

$$k_{80} = \frac{ln\left(\frac{\hat{u}_{80}}{\hat{u}_{65}}\right)}{15} \qquad s = -\frac{ln\left(\frac{\hat{u}_{79}}{\hat{u}_{110}}\right) + 31k_{80}}{465} \qquad \hat{u}_{110} = \begin{cases} 1.0 & men \\ 0.8 & women \end{cases}$$

The Coale & Kisker model fixes u110 to be equal to 0.8 (females) and 1 (males) (Coale & kisker, 1990. Quashie & Denuit, 2005)

In our application, this parameters is defined by the optimisation process. The same for the K parameter

Old ages mortality Models

Modified formula – Coale & Kisker

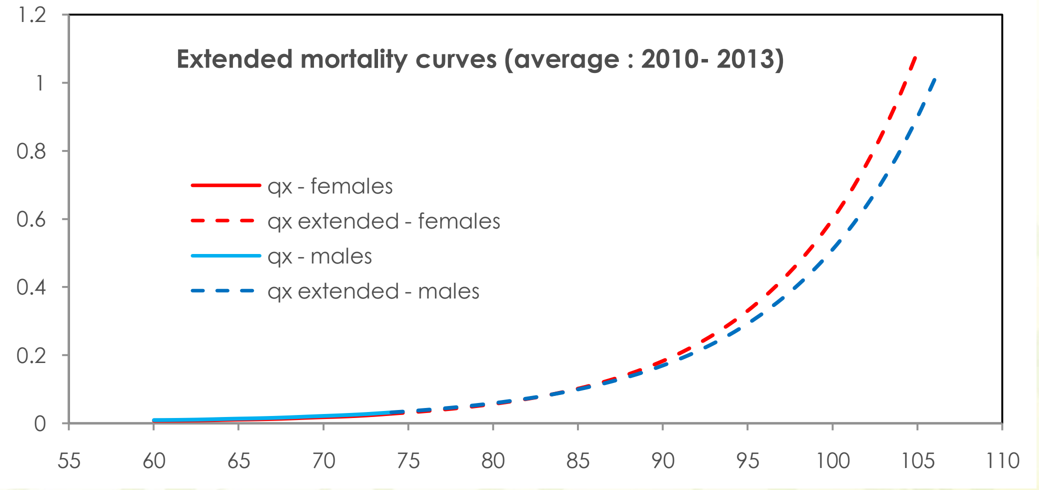
-For our application, we consider:

$$\hat{q}_x = \hat{q}_{x-1} \exp\left(k_{74} + s.(x-74)\right) \quad x = 74, 75, 76, \ldots, 109.$$

$$k_{74} = \frac{ln\left(\frac{\hat{q}_{74}}{\hat{q}_{67}}\right)}{7} \qquad s = -\frac{ln\left(\frac{\hat{u}_{74}}{\hat{u}_{110}}\right) + 36k_{74}}{666}$$

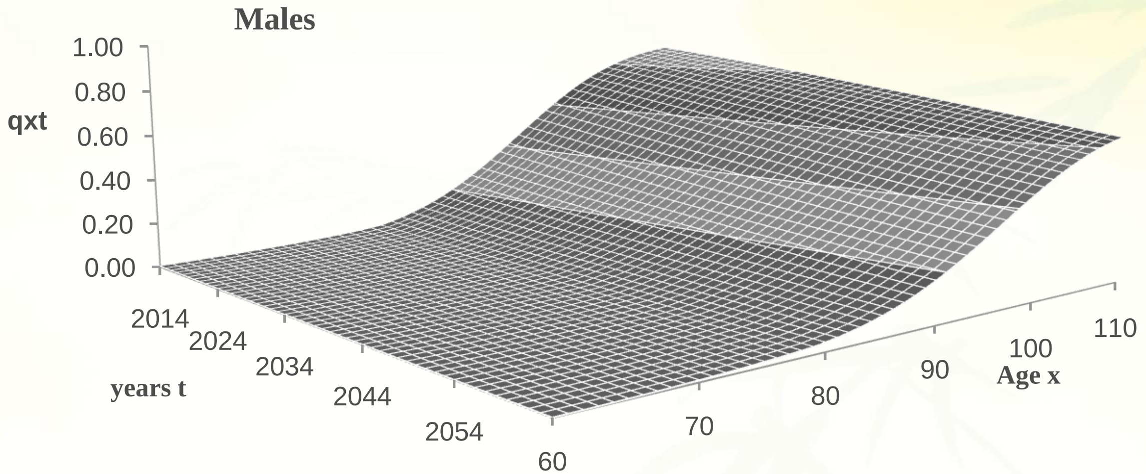
Results

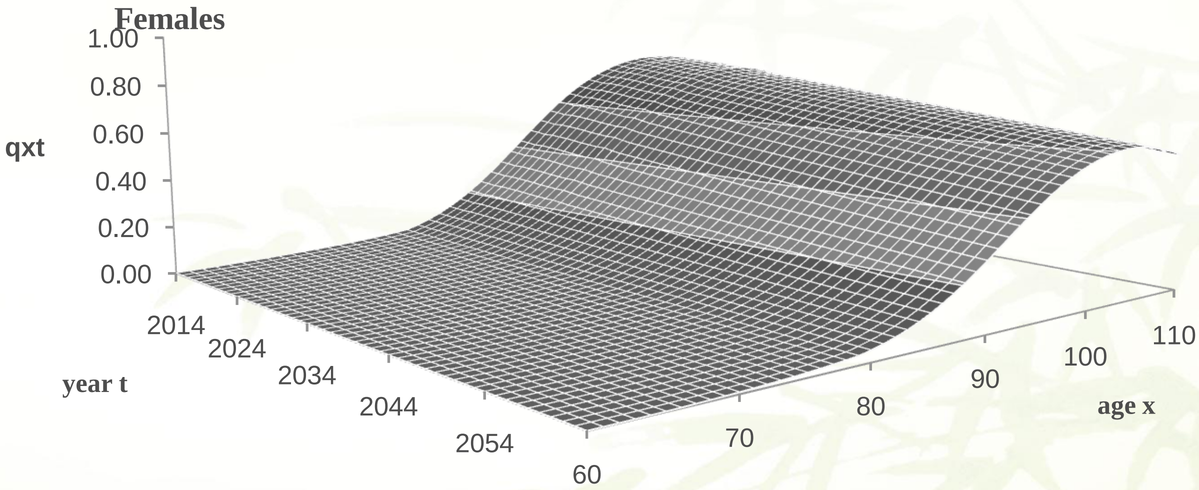
	Males	Females
q110	1,60	1,98
k75	0,1006	0,1153
K- age Range	67- 74	67 - 74
S	0,00043662	0,0001492
MPAD	0,94%	0,90%
Age limit	106	105



Under female mortality beyond the age of 84

Projected mortality surface





Mathematical Reserves calculation

Probability to be alive at time t, for individual x age

$$\hat{P}_{xt} = \exp(-\hat{\mu}_{xt})$$

Probability of survival between the calculation date 't' and the annuity payment date (t+n):

$$_n\hat{P}_{xt} = \prod_{t=0}^{n-1} \hat{P}_{x+i,t+i}$$

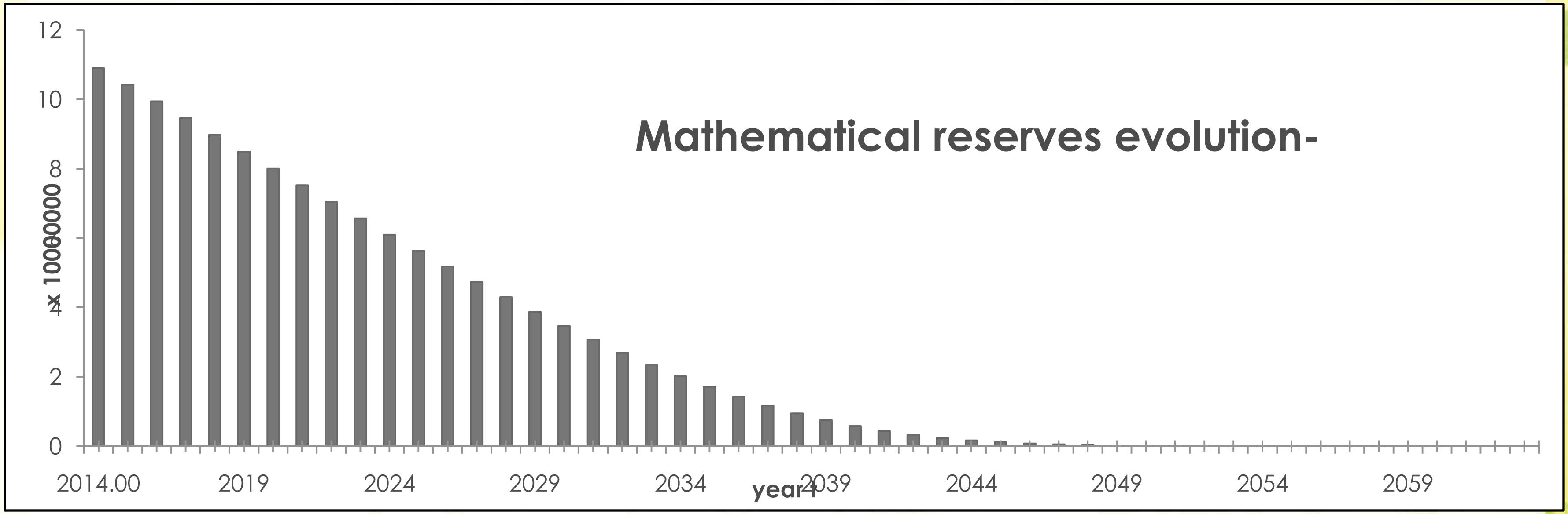
Mathematical reseves for annuitants aged s years old:

$$RM_{st} = N_{st}\,.R_s.\,\ddot{a}_x(t)$$

$\ddot{a}_x(t)$ Expected actual value of annuities to pay until the ultimate age

$$\ddot{a}_x(t) = 1 + {}_1\hat{P}_{xt}.V + {}_2\hat{P}_{xt}V^2 + {}_3\hat{P}_{xt}V^3 + .. + {}_{(w-x-1)}\hat{P}_{xt}V^{w-x-1}$$

Mathematical Reserves



Portfolio : 1400 anuitants in pay

i= 3% (public bonds – Algeria)

RM(2014) = 110 000 000 dzd)

Conclusion

• mortality is increasing : it's necessary to use dynamic life table;

•considering the specifities of the algerian data

•Adding extra time compononents has to improve the fitting quality

• Extending mortality to old ages : information lack beyond the age of 85.

•Under female mortality at the old ages : the same for the belgian population beyong the age of 76 (Brouhns & al. 2002)

•Mortality projection : with 4 components, the irregularity of Kt series is importante – use ARIMA time serie models to project (Li, Hardy and Tan)

•Dynamic life table allows more accurate calculations (reserving – pricing)

Thank you for your attention