

Family History and Life Insurance

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Online International Conference
in Actuarial science, data science and finance



Agenda

Motivations

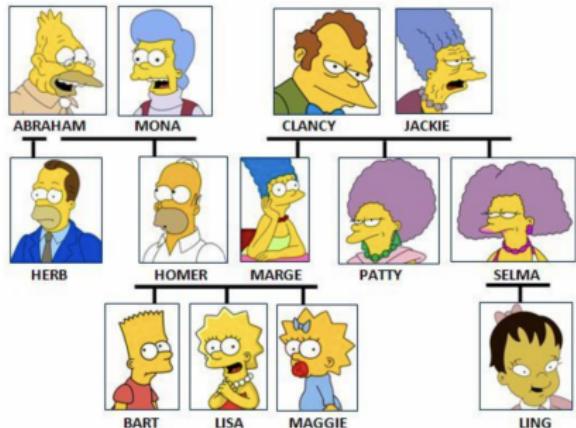
Genealogical Data

'Family History' & Life Insurance

Husband-Wife

Children-Parents

Grand Children-Grand Parents



Using genealogical trees to understand dependencies in life spans
and quantify the impact on (life related) insurance premiums

'Family History' & Insurance Forms

Family History: (Please Note The Family Member & Maternal (M) OR Paternal (P) When Appropriate):

Breast Cancer: _____ Colon Cancer: _____
Diabetes: _____ Genetic Disorders: _____
Heart Disease: _____ High Blood Pressure: _____
Kidney Disease: _____ Lung Cancer: _____
Osteoporosis: _____ Other Cancer: _____
Ovarian Cancer: _____ Ovarian Cancer: _____
Stroke/DVT/Clotting/Bleeding Disorder: _____
Thyroid Disease: _____ Uterine Cancer: _____
Other: _____

Family History (family history is a consideration for each rate class):

To your knowledge, is there any family history (parent or siblings), prior to age 60, of cardiovascular disease, cerebrovascular disease, heart disease, stroke, diabetes, or cancer?

Yes No

If yes, provide full details:

- Father: Impairment _____ Age at Onset _____ Age at Death (if deceased) _____
 Mother: Impairment _____ Age at Onset _____ Age at Death (if deceased) _____
 Siblings: Impairment _____ Age at Onset _____ Age at Death (if deceased) _____

FAMILY HISTORY:

Please check the box if your family has a history of:

- Diabetes High Blood Pressure Heart Attack, Heart Disease
 Cancer Alzheimer's Family History Unknown Blood Clots or Stroke Tuberculosis
 Mental Illness Epilepsy/Seizure

Any other major conditions? _____

If you answered Yes to any of the above, please explain: _____

Are you currently being treated for medical conditions? Yes No If yes, please list: _____

Family Medical History

Age

Diseases

If Deceased, Cause of Death

Father _____

Mother _____

Siblings _____

Spouse _____

Children _____

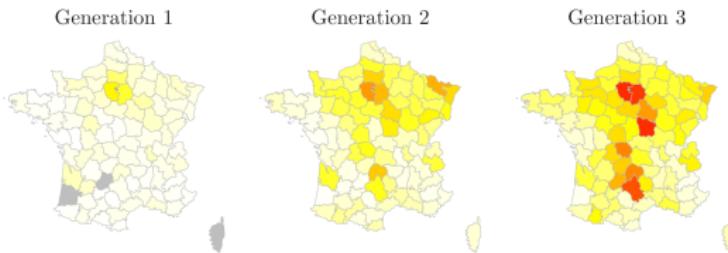
Genealogical Data

Charpentier and Gallic (2020a) comparing our collaborative based dataset (238,009 users, 1,547,086 individual born in [1800, 1805]), with official historical data

ID_user	ID_np	ID_num	Name tabular	Surname	Sex	Date_b
1 daage	besnard jean 1	575	BESNARD	Jean	1	18000227
2 denisgallienne	besnard louis 1	22771	BESNARD	Louis	1	18040603
3 domiassi	besnard jean	1748	BESNARD	Jean	1	18000227
4 dutheilfr	besnard pierre	729	BESNARD	Pierre	1	18001221
5 dvivier1	besnard louis 1	65196	BESNARD	Louis	1	18001215

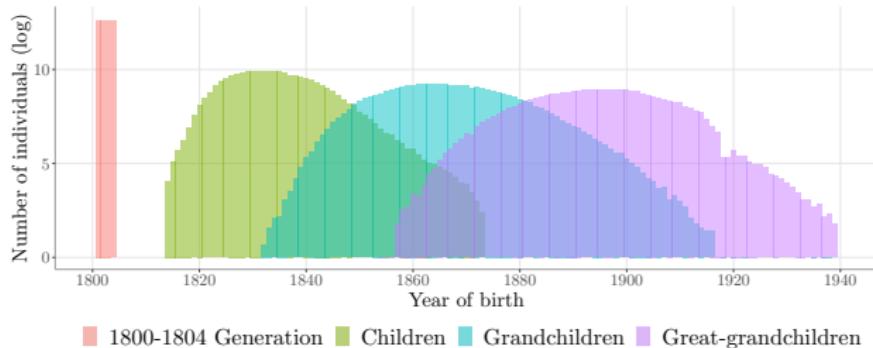
Date_d	Type	Location	Lat	Long	ID_num_m	ID_num_p
1 16810000	NM	Longué, 0180	47.37806	-0.10806	4457	574
2 18831027	ND	Cunault, 49350	47.30833	-0.15389	994	1620
3 18560000	NM	Longué, 49180	47.37806	-0.10806		
4	N	Gennes, 49350	47.34083	-0.23278	99	59
5 18490717	N	Pommeraye, 49244	47.35528	-0.86028	43116	4063

Charpentier and Gallic (2020b) on generational migration



Genealogical Data & “Generations”

Initial starting generation (born in [1800, 1805])
then children (born ~ [1815, 1870]), grand children (born ~ [1830, 1915]), grand grand children (born ~ [1850, 1940])



■ 1800-1804 Generation ■ Children ■ Grandchildren ■ Great-grandchildren

Demographic & Insurance Notations

$${}_t p_x = \mathbb{P}[T(x) > t] = \mathbb{P}[T-x > t | T > x] = \frac{\mathbb{P}[T > t+x]}{\mathbb{P}[T > x]} = \frac{S(x+t)}{S(x)}.$$

curtate life expectancy for T_x is defined as

$$e_x = \mathbb{E}(\lfloor T_x \rfloor) = \mathbb{E}(\lfloor T - x \rfloor | T > x) = \sum_{t=0}^{\infty} t {}_t p_x \cdot q_{x+t} = \sum_{t=1}^{\infty} {}_t p_x,$$

actuarial present value of the annuity of an individual age (x) is

$$a_x = \sum_{k=1}^{\infty} \nu^k {}_k p_x \text{ or } a_{x:\bar{n}} = \sum_{k=1}^n \nu^k {}_k p_x,$$

and whole life insurance (see Bowers et al. (1997))

$$A_x = \sum_{k=1}^{\infty} \nu^k {}_k p_x \cdot q_{x+k} \text{ or } A_{x:\bar{n}}^1 = \sum_{k=1}^n \nu^k {}_k p_x \cdot q_{x+k}.$$

Historical Mortality

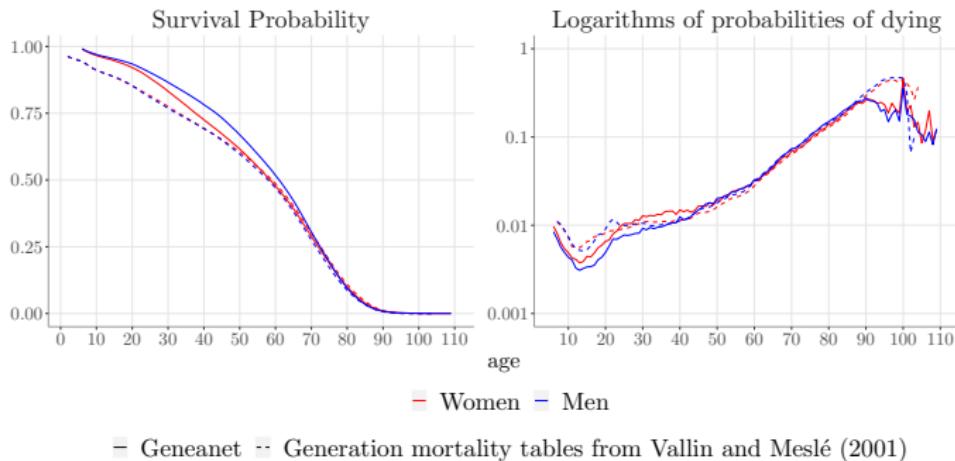
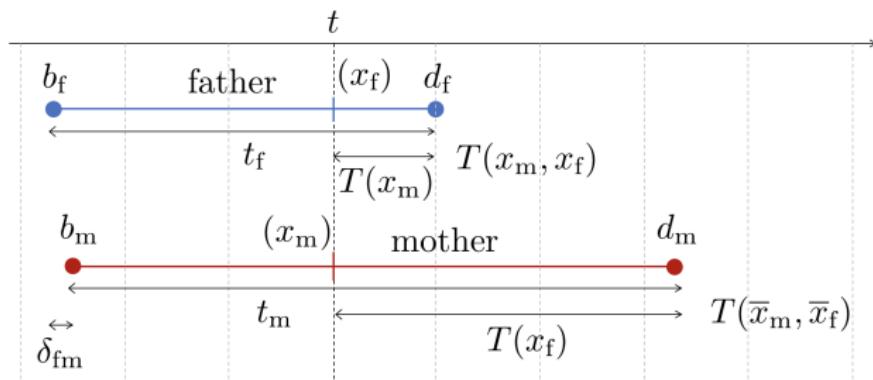


Figure 1: Survival distribution ${}_t p_0 = \mathbb{P}[T > t]$ and force of mortality ${}_1 q_x = \mathbb{P}[T \leq x + 1 | T > x]$ (log scale), against historical data.

Husband-Wife dependencies

i	birth (b_f)	death (d_f)	age (t_f)	birth (b_m)	death (d_m)	age (t_m)
	$b_{f,i}$	$d_{f,i}$	$t_{f,i}$	$b_{m,i}$	$d_{m,i}$	$t_{m,i}$
1	1800-05-04	1835-02-22	34.80356	1762-07-01	1838-01-19	75.55099
2	1778-02-09	1841-02-02	62.97878	1758-07-05	1825-08-03	67.07734
3	1771-01-18	1807-01-17	35.99452	1752-12-28	1815-10-31	62.83641
4	1768-07-01	1814-10-15	46.28611	1768-07-01	1830-12-06	62.42847
5	1766-07-01	1848-01-12	81.53046	1767-02-10	1851-04-22	84.19165
6	1769-06-28	1836-08-28	67.16496	1773-12-17	1825-02-15	51.16222

Table 1: Dataset for the joint life model, father/husband (f) and mother/spouse (m)



Husband-Wife dependencies - Temporal Stability

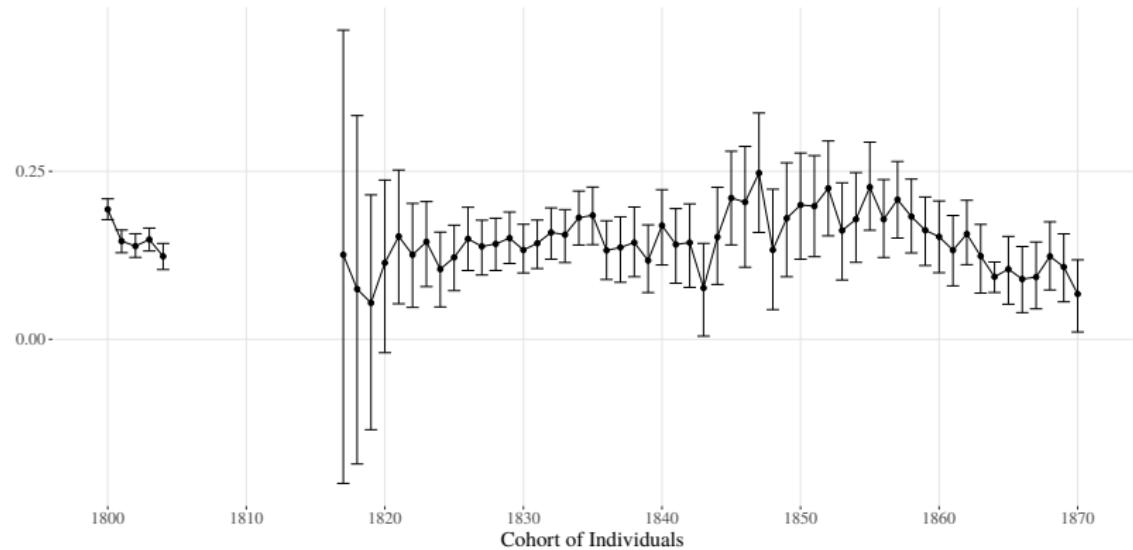


Figure 2: Spearman correlation (T_f, T_m) - per year of birth of the father.

Husband-Wife dependencies

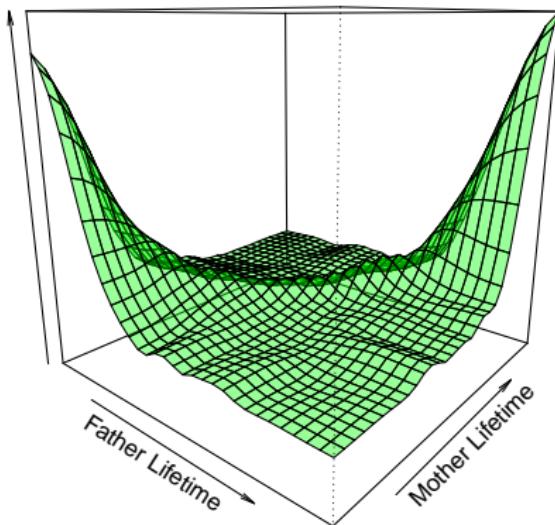


Figure 3: Nonparametric estimation of the copula density, (T_f, T_m).

see Frees et al. (1996), Carriere (1997), or Denuit et al. (2001)
Here $\widehat{\rho_S} = 0.168$, 95% confidence interval (0.166; 0, 171)

Husband-Wife dependencies

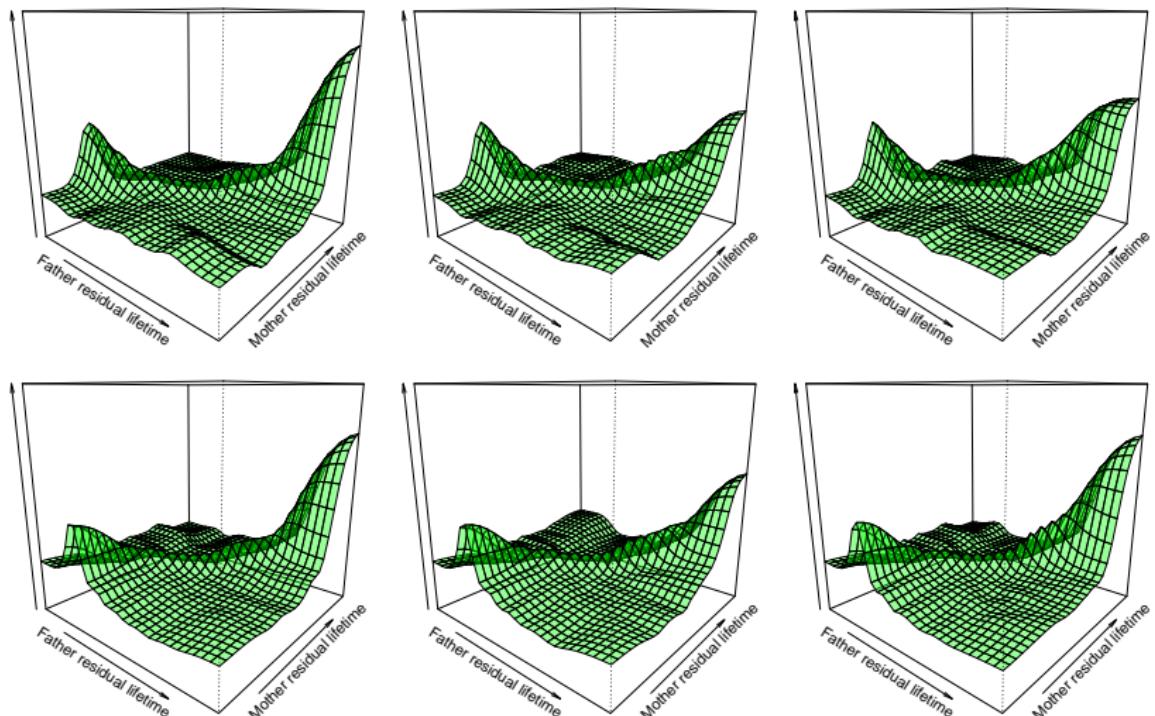


Figure 4: Copula density of remaining life times (T_f, T_m) given $T_f \geq x$ (father on top, mother below).

Husband-Wife dependencies

Multiple life quantities, e.g. widow's pension,

$$a_{m|f} = \sum_{k=1}^{\infty} \nu^k k p_{x_f} - \sum_{k=1}^{\infty} \nu^k k p_{x_f, x_m}, \text{ where } {}_t p_{x_f, x_m} = \mathbb{P}[T_{x_f} > t, T_{x_m} > t,]$$

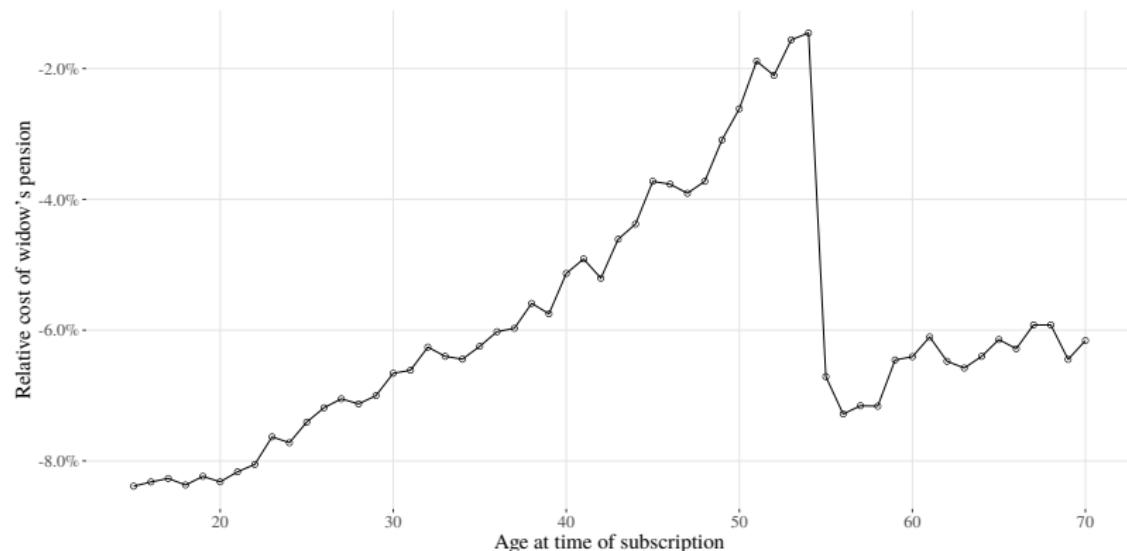


Figure 5: Widow's pension, $a_{m|f}$ (relative to independent case $a_{m|f}^\perp$).

Children-Parents

“inheritance of longevity”
coined in Pearl (1931)

“the life spans of parents and children appear only weakly related, even though parents affect their children’s longevity through both genetic and environmental influences”

Vaupel (1988)

“the chance of reaching a high age is transmitted from parents to children in a modest, but robust way”

Vågerö et al. (2018)

Fig. 3.
Regression Line : Fathers on Sons.

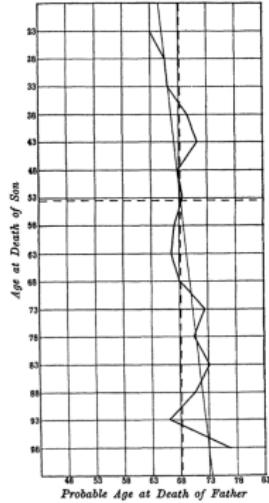


Fig. 4.
Regression Line : Mothers on Sons.

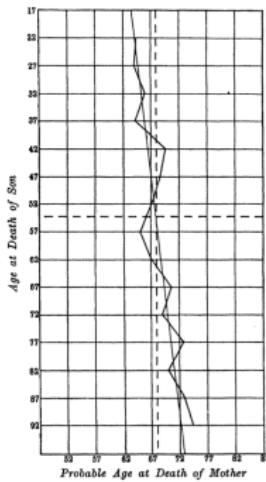


Figure 6: Son vs. parents Beeton and Pearson (1901).

Children-Parents

Beeton and Pearson (1901), regression of T_{X_c} given T_{X_f} or T_{X_m}

slope :

- Daughter–mother
0.1968 [0.1910, 0.20260]
- Son–mother
0.1791 [0.1737, 0.18443]
- Daughter–father
0.1186 [0.1122, 0.12507]
- Son–father
0.1197 [0.1138, 0.12567]

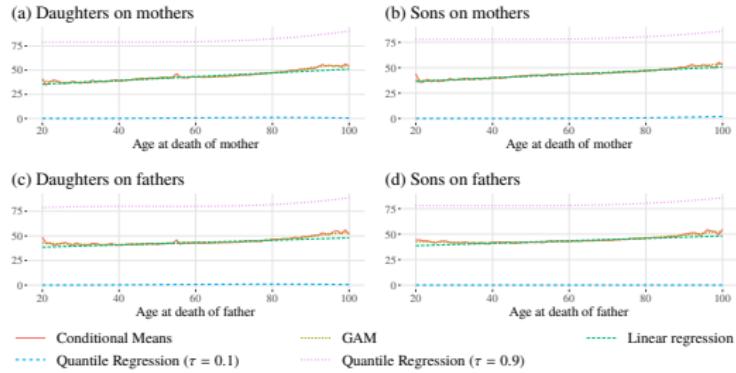


Figure 7: Age of the children given information relative to the parents.

Children-Parents

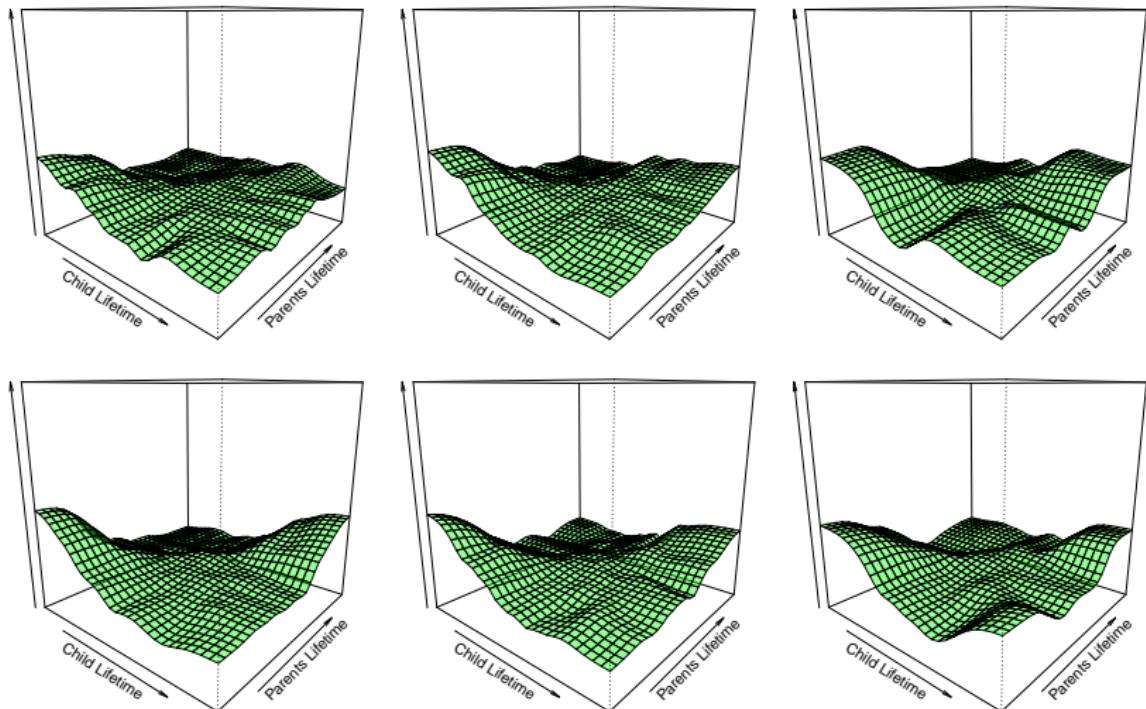


Figure 8: Copula density, children and father/mother/min/max.

Children-Parents, life expectancy

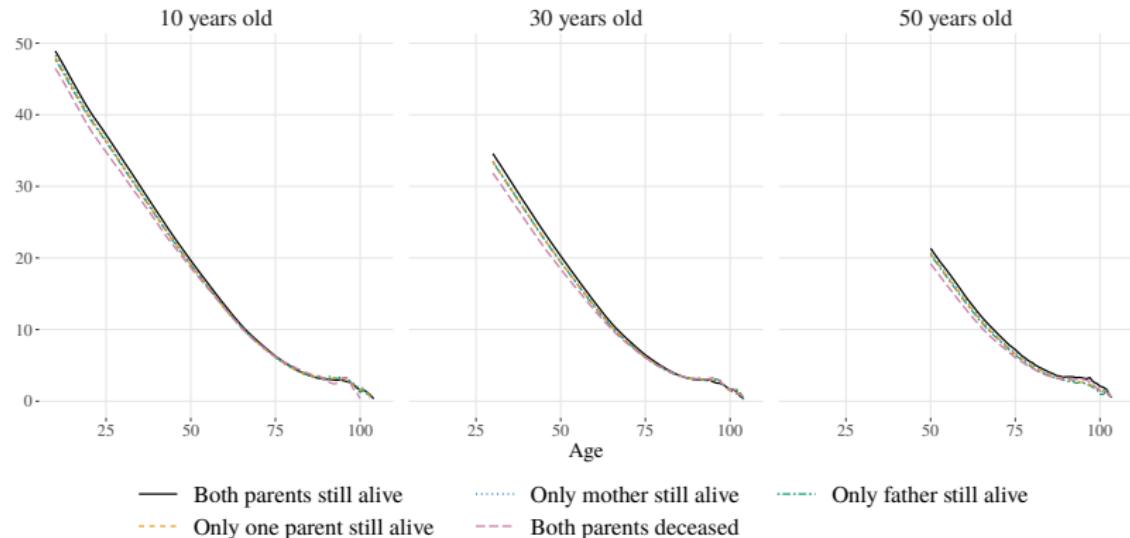


Figure 9: Residual life expectancy e_x with information about parents at age 10, 30 or 50.

Children-Parents, annuities and insurance

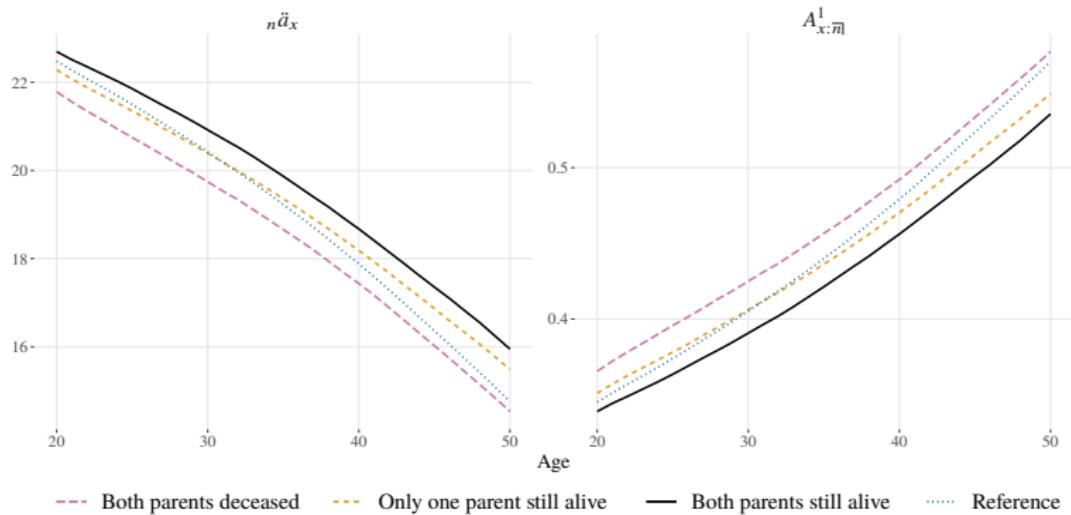


Figure 10: Annuity a_x and whole life insurance A_x , given information about the number of parents still alive, when child has age x .

Children-Parents, annuities and insurance

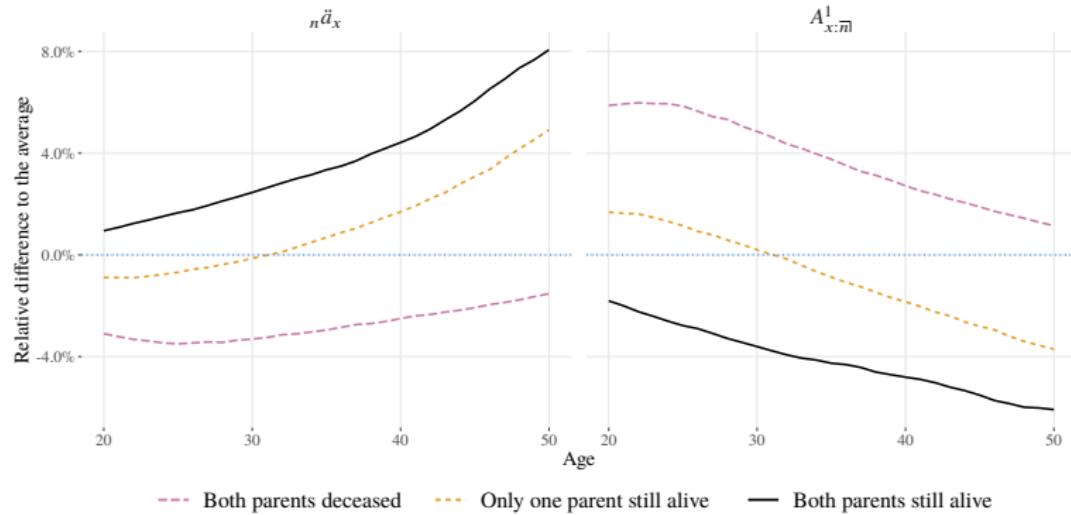


Figure 11: Annuity a_x and whole life insurance A_x , given information about the number of parents still alive, when child has age x (relative difference).

Children-Grand Parents

Choi (2020), “*little is known about whether and how intergenerational relationships influence older adult mortality*”

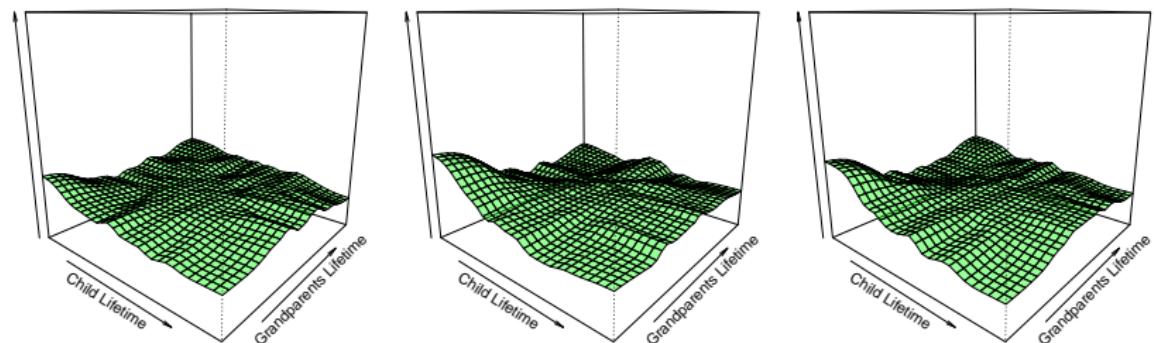


Figure 12: Copula density, children and grand parents min/max/mean.

Children-Grand Parents, life expectancy

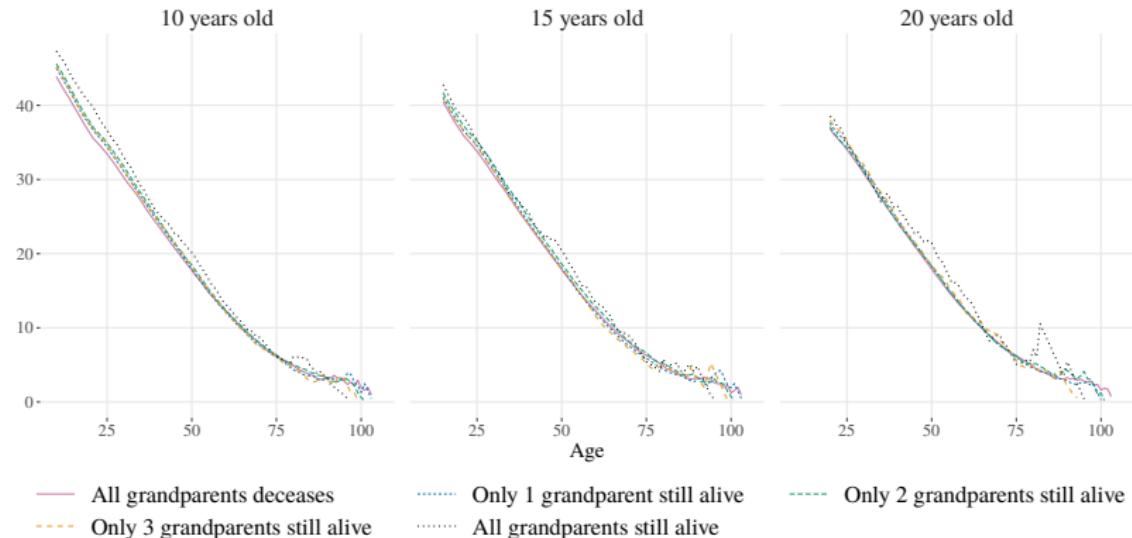


Figure 13: Residual life expectancy e_x with information about parents at age 10, 15 or 20.

Children-Grand Parents, annuities and insurance

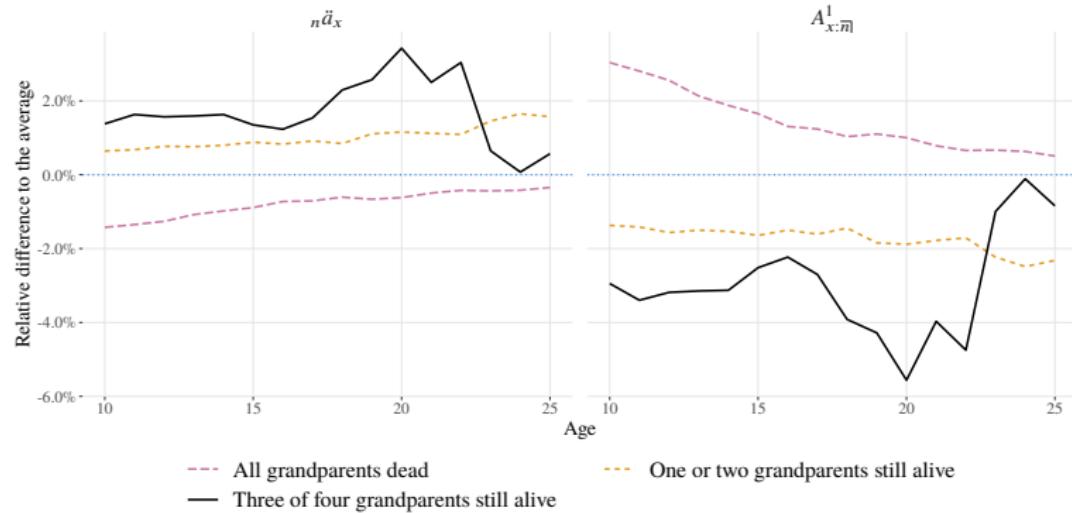


Figure 14: Annuity a_x and whole life insurance A_x , given information about the number of grand parents still alive, when child has age x .

References

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