Basin-wide patterns in age-at-maturity

Steve Haeseker
U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office

Comparative Survival Study Oversight Committee

Age at maturity

Age composition of returning adults (by brood or smolt migration year)

Why is maturity important?

1) forecasting models

2) population productivity

3) fisheries

Can vary across populations and over time

Where? When? Why

Age at maturity data

Requires adult sampling	Potential issues
Scales	Aging error, source population
Coded wire tags	Expansion factors, reading tags, high sampling effort, little coverage of wild stocks

PIT tags
- negligible aging error
- known population and individual ID
- high sampling rates
- consistent sampling effort across stocks
- near real-time observations, non-lethal
- coverage of some wild stocks

Summarizing age at maturity data

Mean age (at maturity):

10% age-3, 70% age-4, 20% age-5 = 4.1 years

Proportions at age:

age-3 returns / total BY returns

Sibling relationships:

age-3 v. age-4 and age-4 v. age-5 regressions

Comparative Survival Study PIT-tag analyses

11 stocks, juvenile outmigration years 1997-2011

Hatchery spring Chinook: Carson, Leavenworth, Cle Elum, Dworshak, Catherine Creek, Rapid River

Hatchery summer Chinook: McCall, Imnaha

Wild spring Chinook: John Day River, Snake River, Yakima River

Longer-term data:

Columbia returns, juvenile migration years 1980-2013

Questions about age at maturity

Is age-at-maturity similar across stocks?

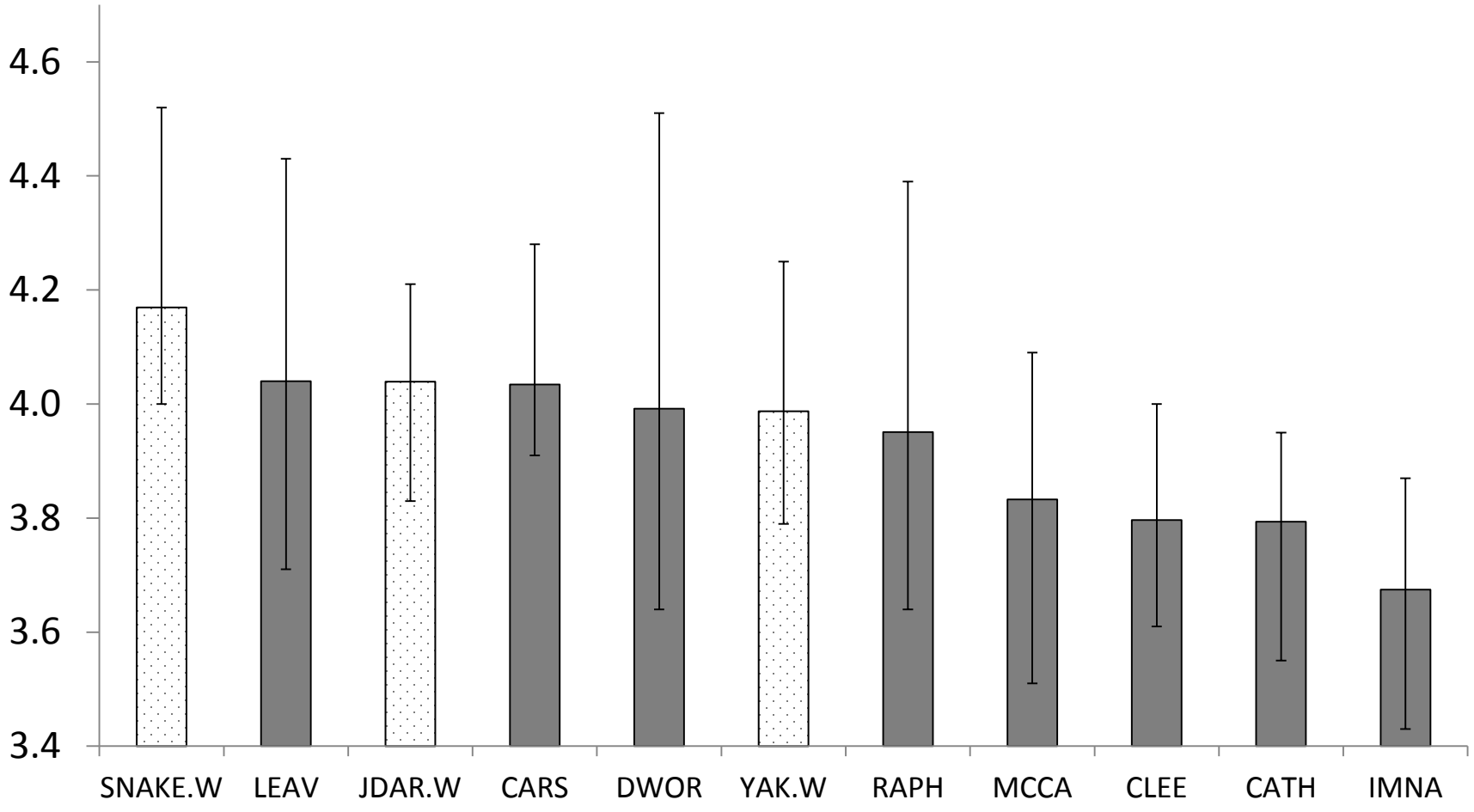
Do overall survival rates (SARs) affect age at maturity?

Does outmigration route affect age at maturity?

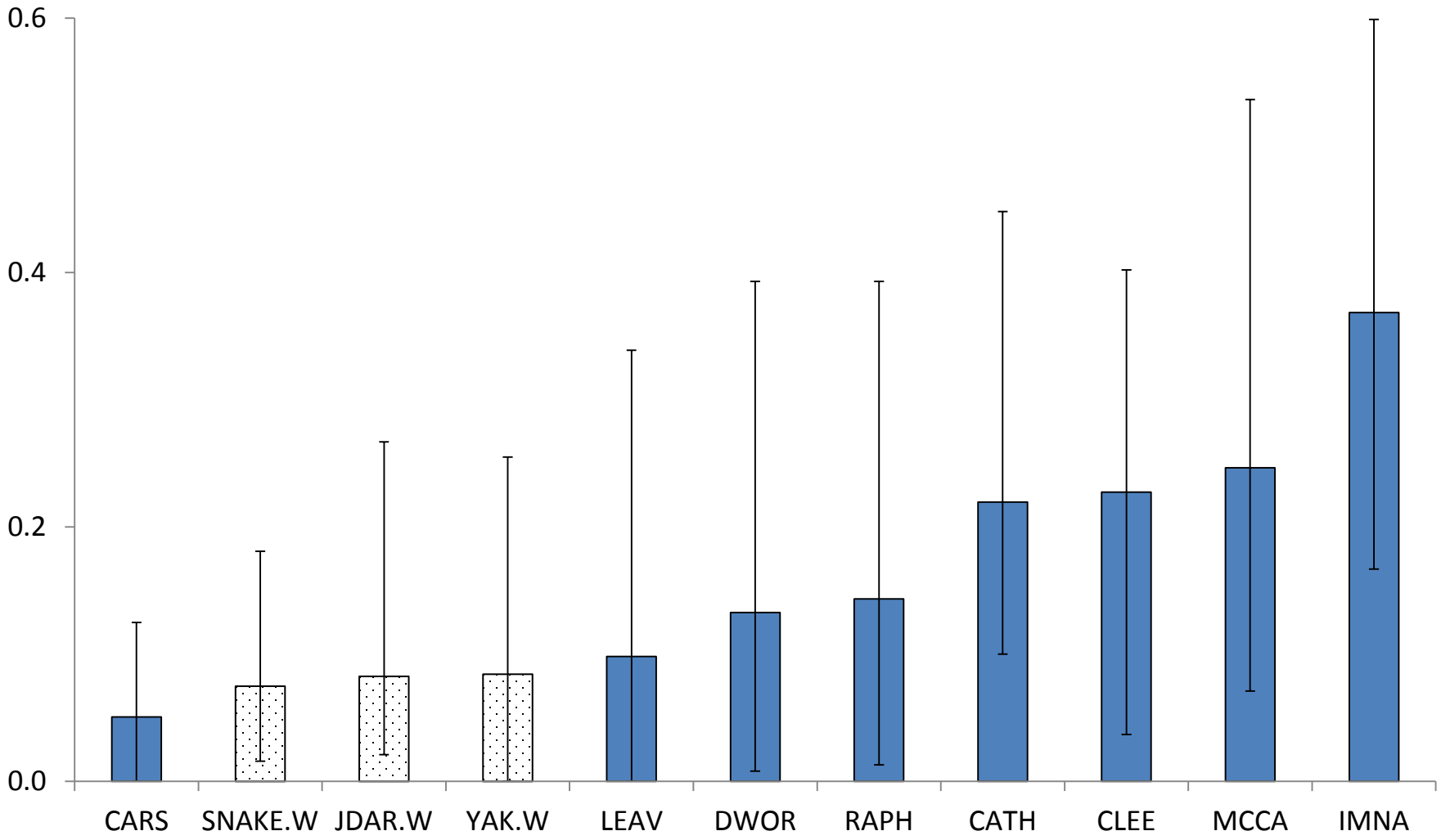
What are the patterns of variation?

- Within and across stocks
- Over time

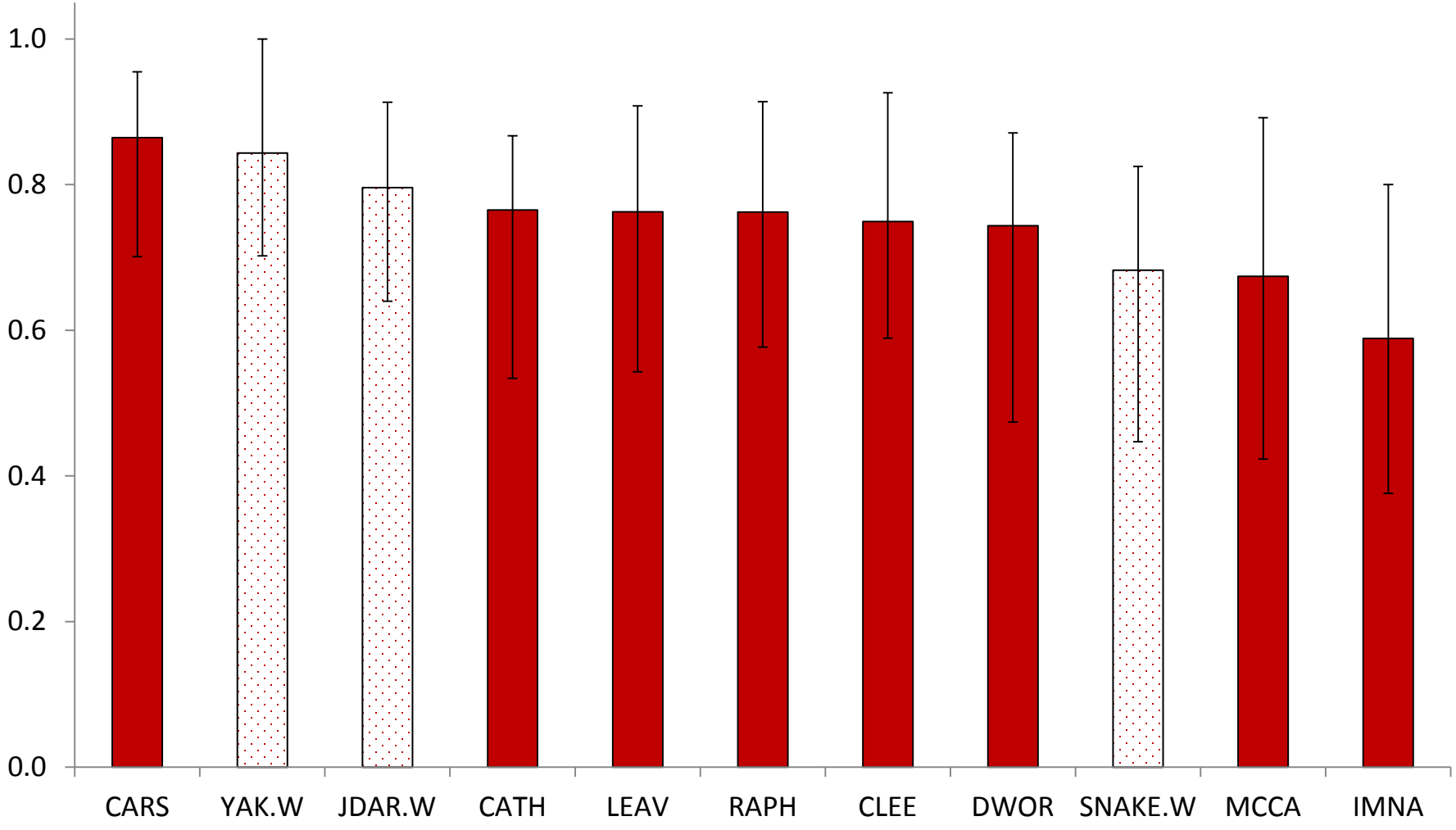
Mean age


4.6
4.4
4.2
4.0
3.8
3.6
3.4
SNAKE.W
LEAV
JDAR.W
CARS
DWOR
YAK.W
RAPH
MCCA
CLEE
CATH
IMNA

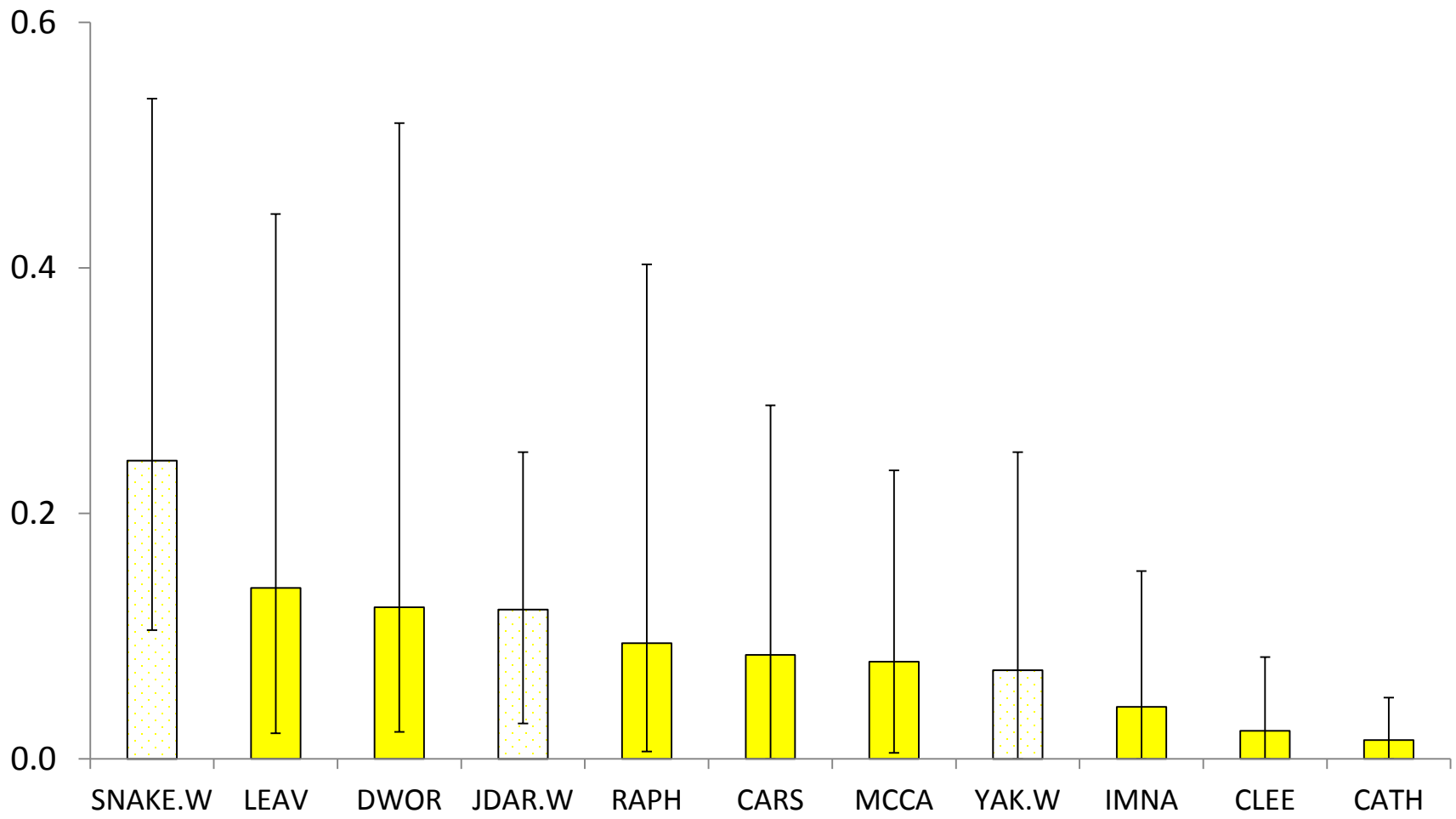
Mean proportion age-3



Mean proportion age-4



Mean proportion age-5



Mean age and proportion-at-age varies by stock

Mean age related to SAR?

Analysis of covariance

Mean age ~ stock + SAR

$P = 0.48$ → No relationship between SAR and mean age

Mean age versus outmigration route?

Paired t-test of transported versus in-river outmigration routes

Stock	*P*-value
Snake River wild	0.43
Catherine Creek AP	0.98
Dworshak	0.76
Rapid River	0.97
McCall	0.47
Imnaha River AP	0.82

No relationship between outmigration route and mean age

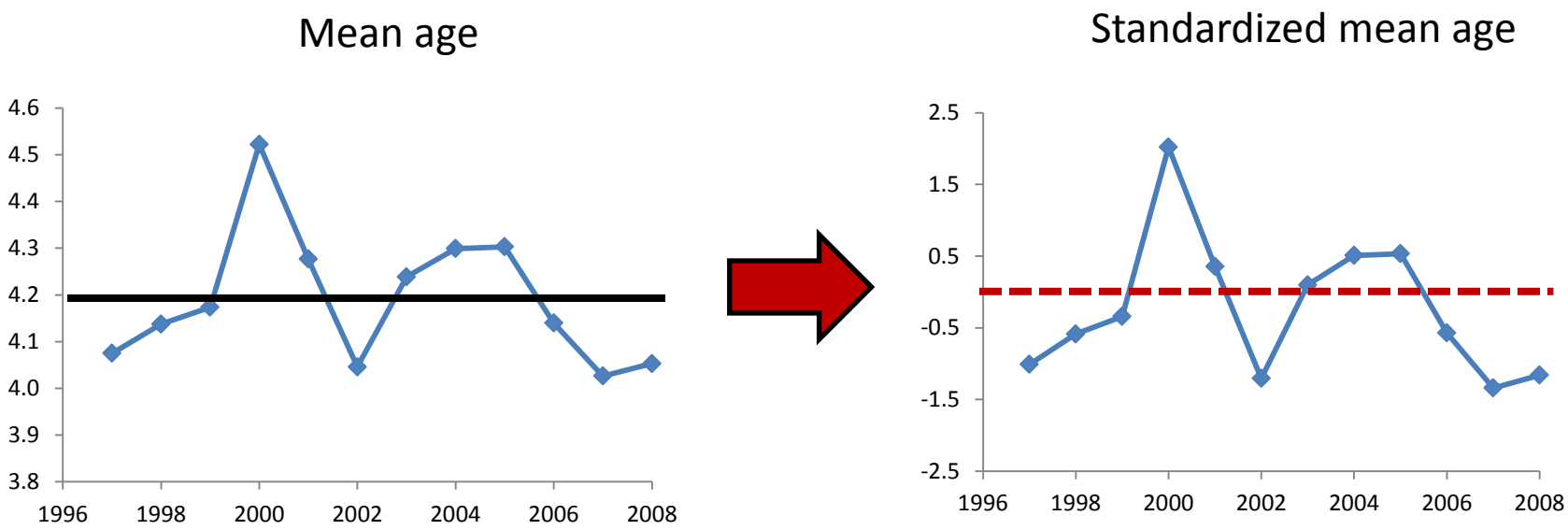
Temporal trends in mean age?

Analysis of covariance

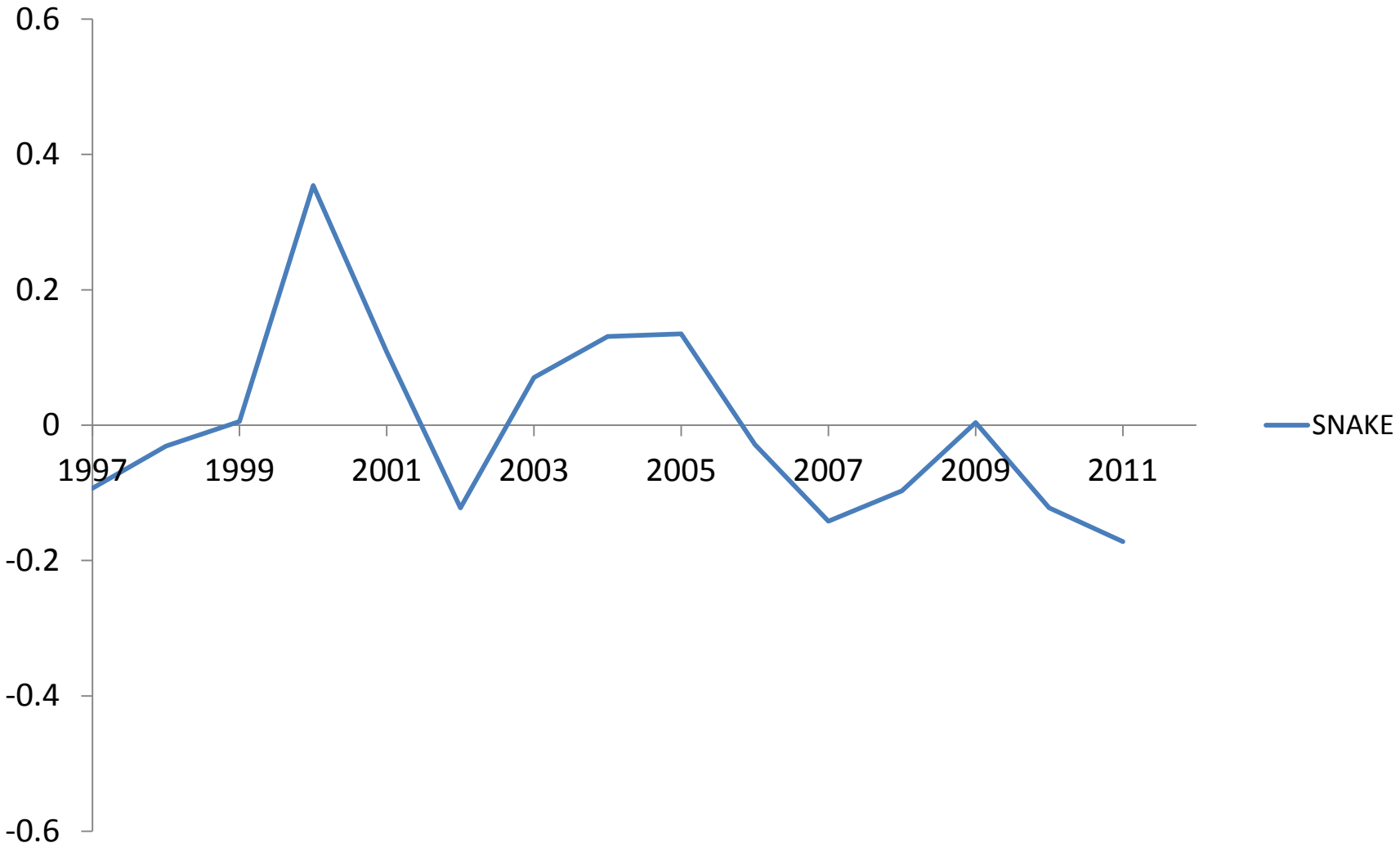
Mean age ~ rear type + migration year

Rear type:	$P < 0.001$	→	Wild fish older
Year:	$P < 0.001$	→	Declining trend in mean age
Rear * Year:	$P = 0.35$	→	Similar trends among H & W
Stock * Year:	$P = 0.50$	→	Similar trends among stocks

Standardizing mean age over time and across stocks



Standardized mean age over time and across stocks



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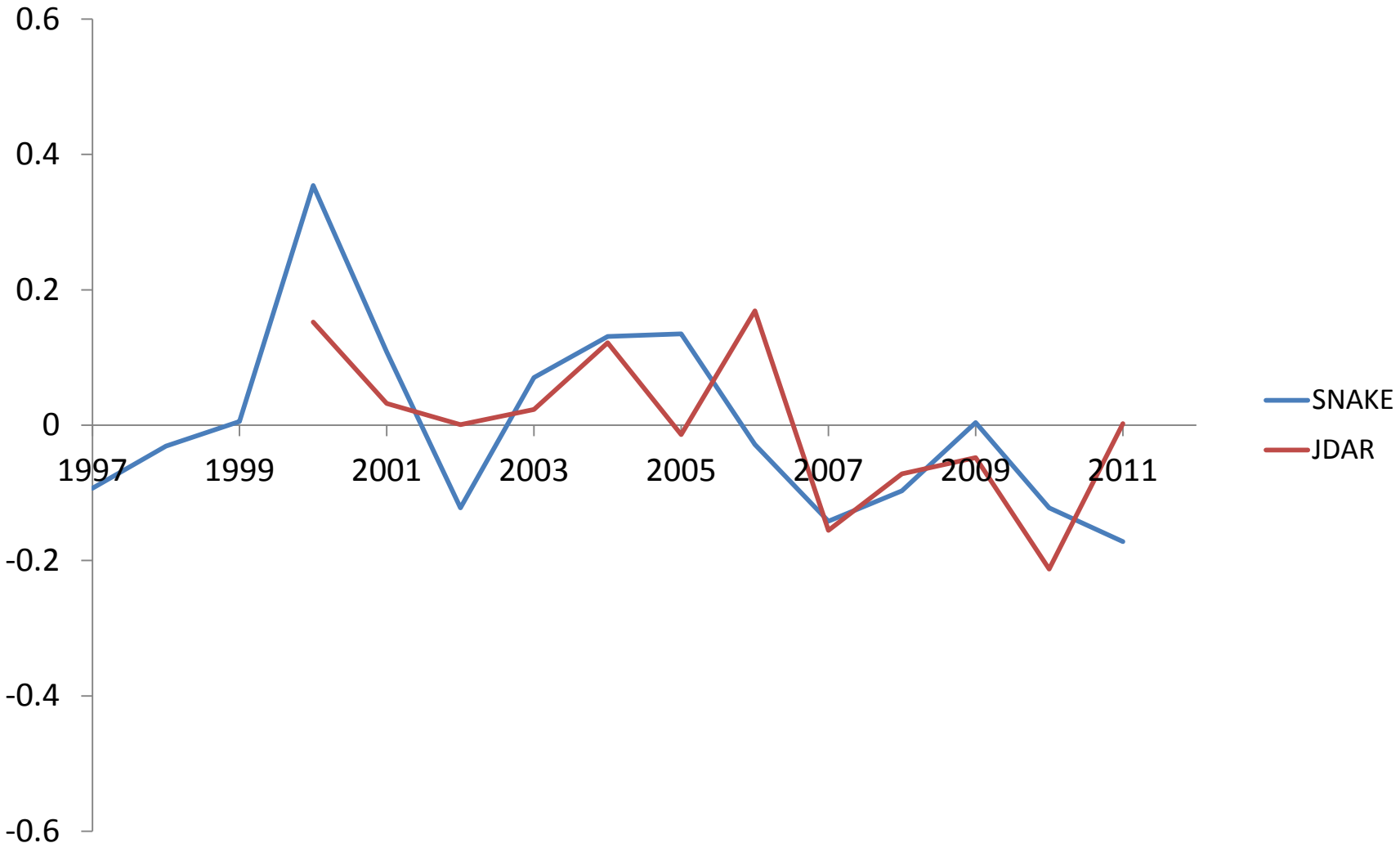

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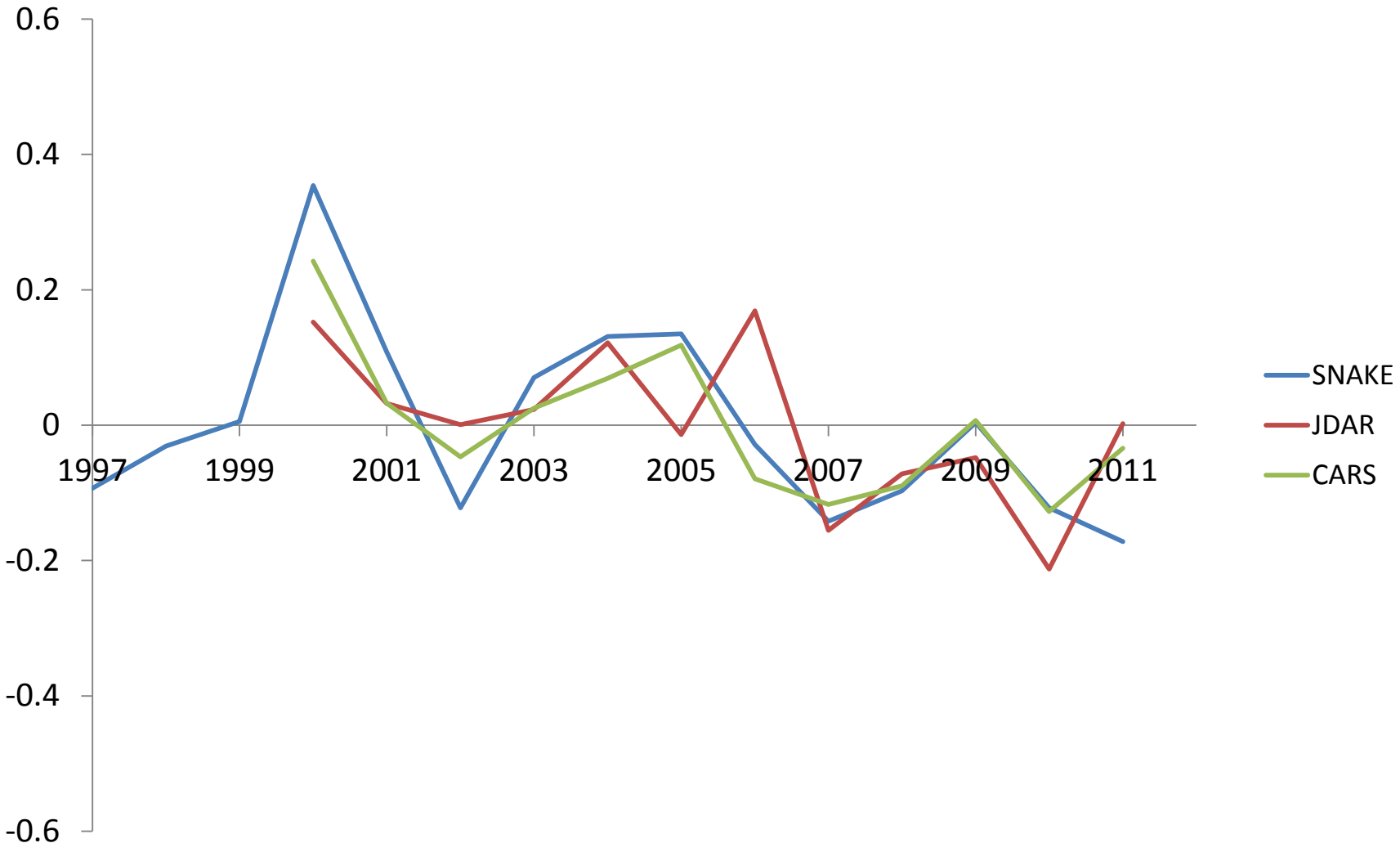

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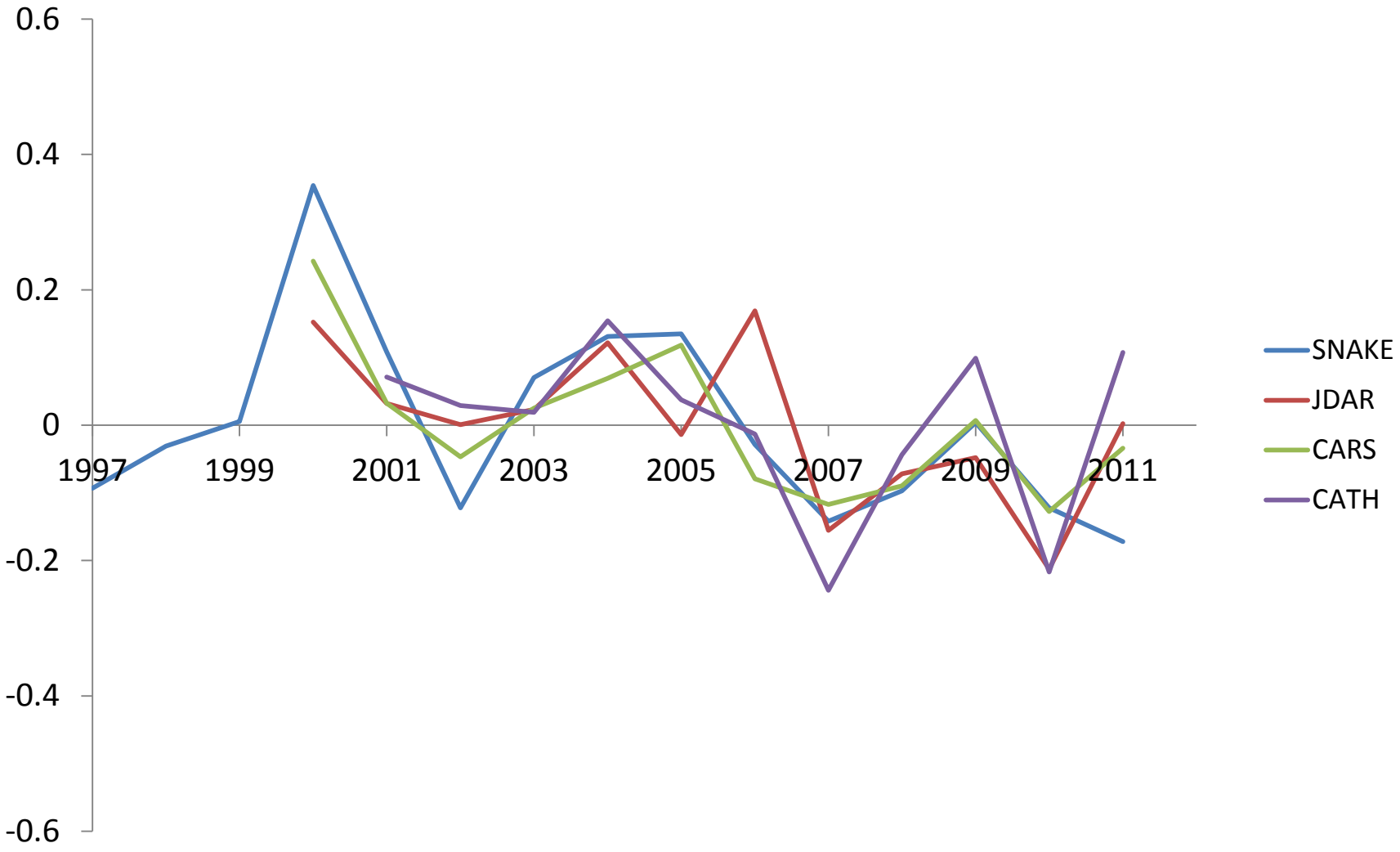

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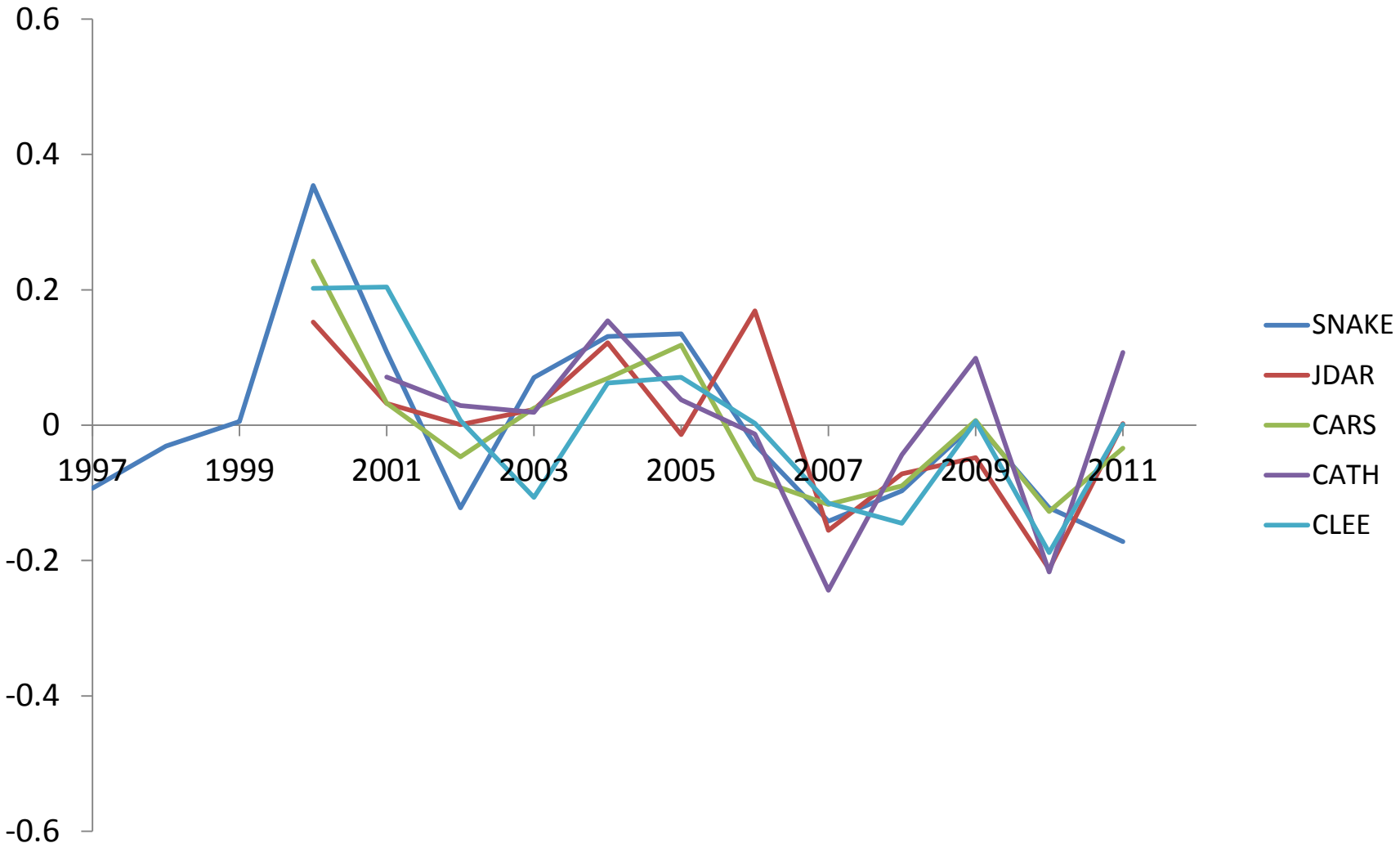

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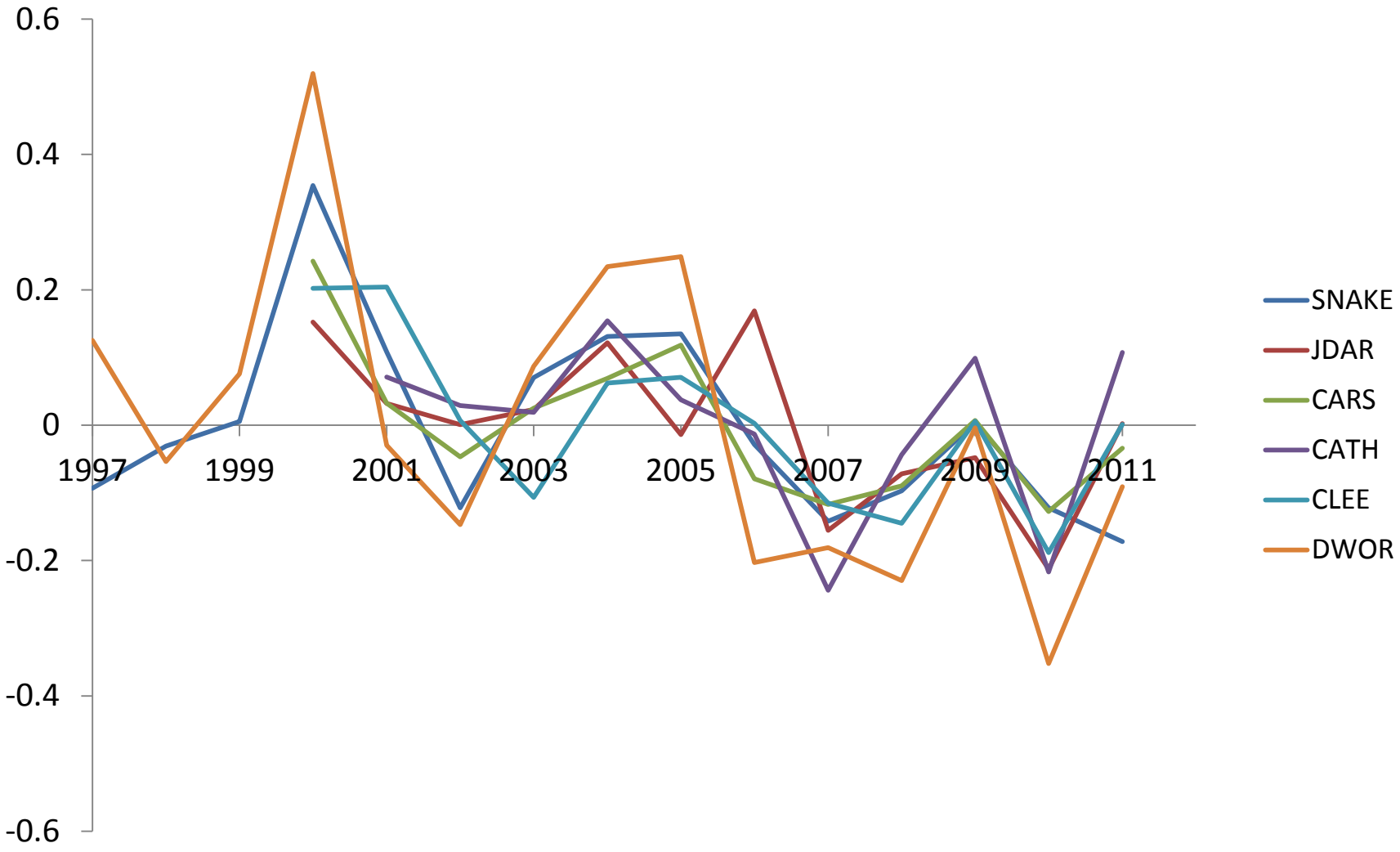
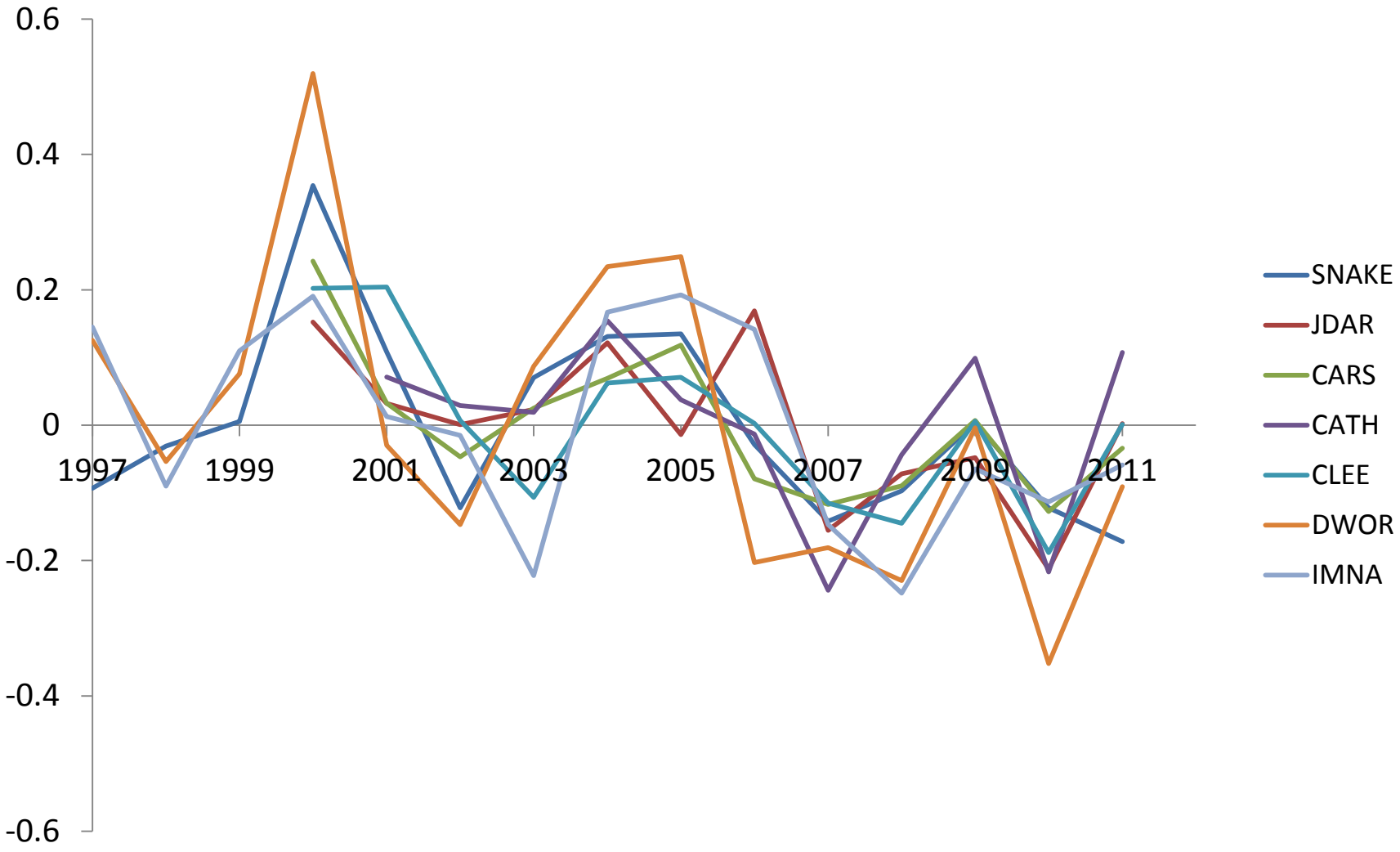


Standardized mean age over time and across stocks



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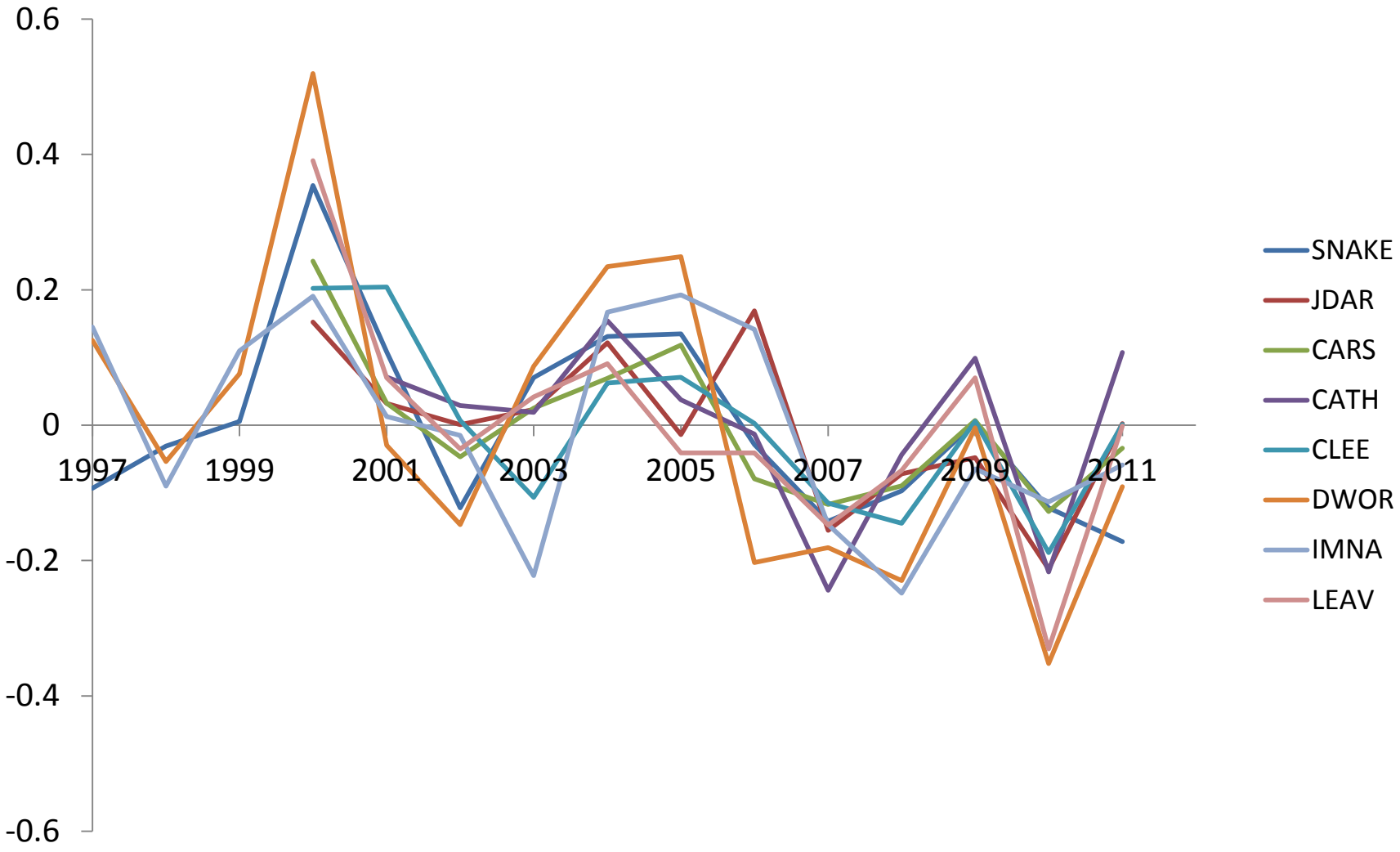

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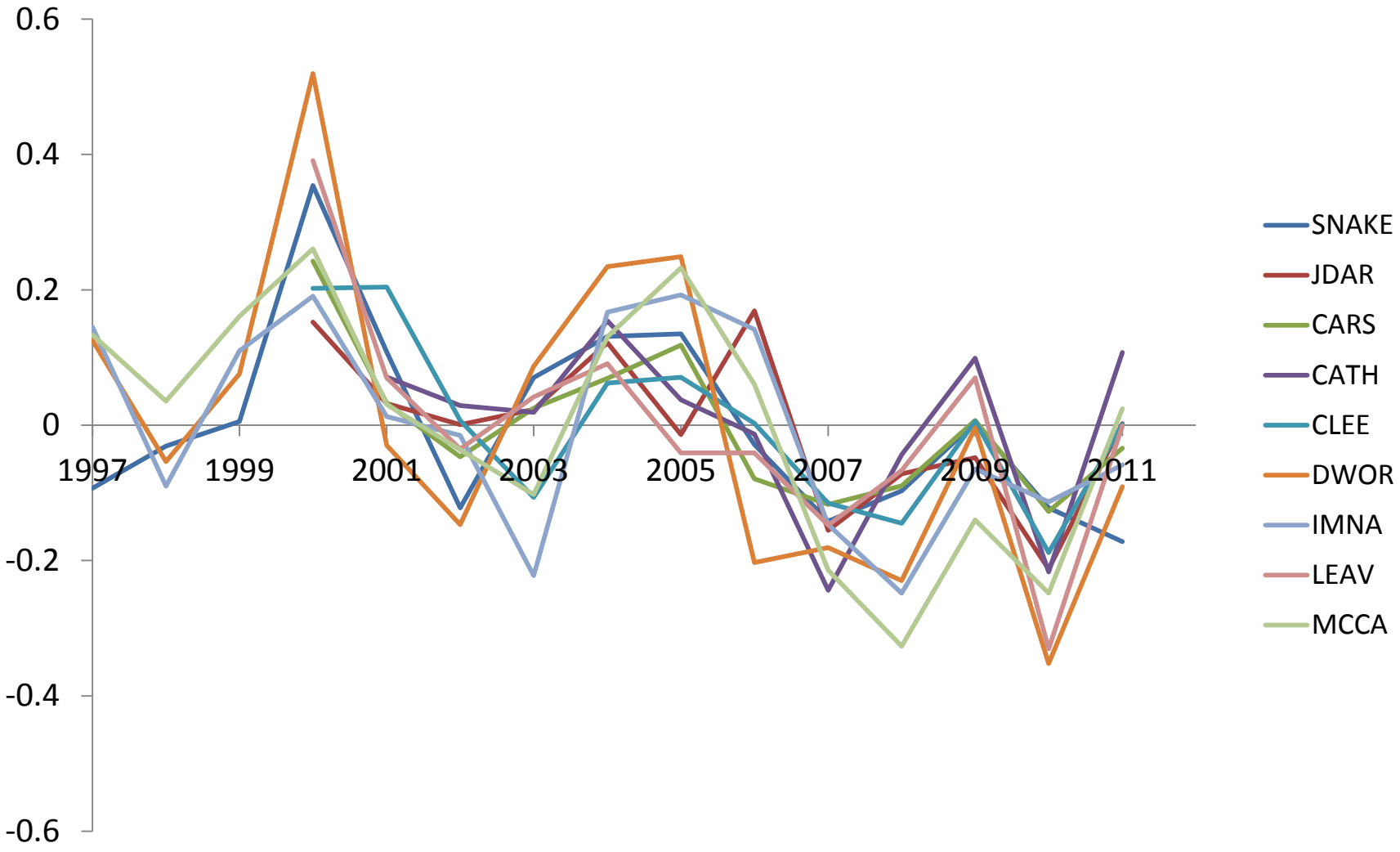

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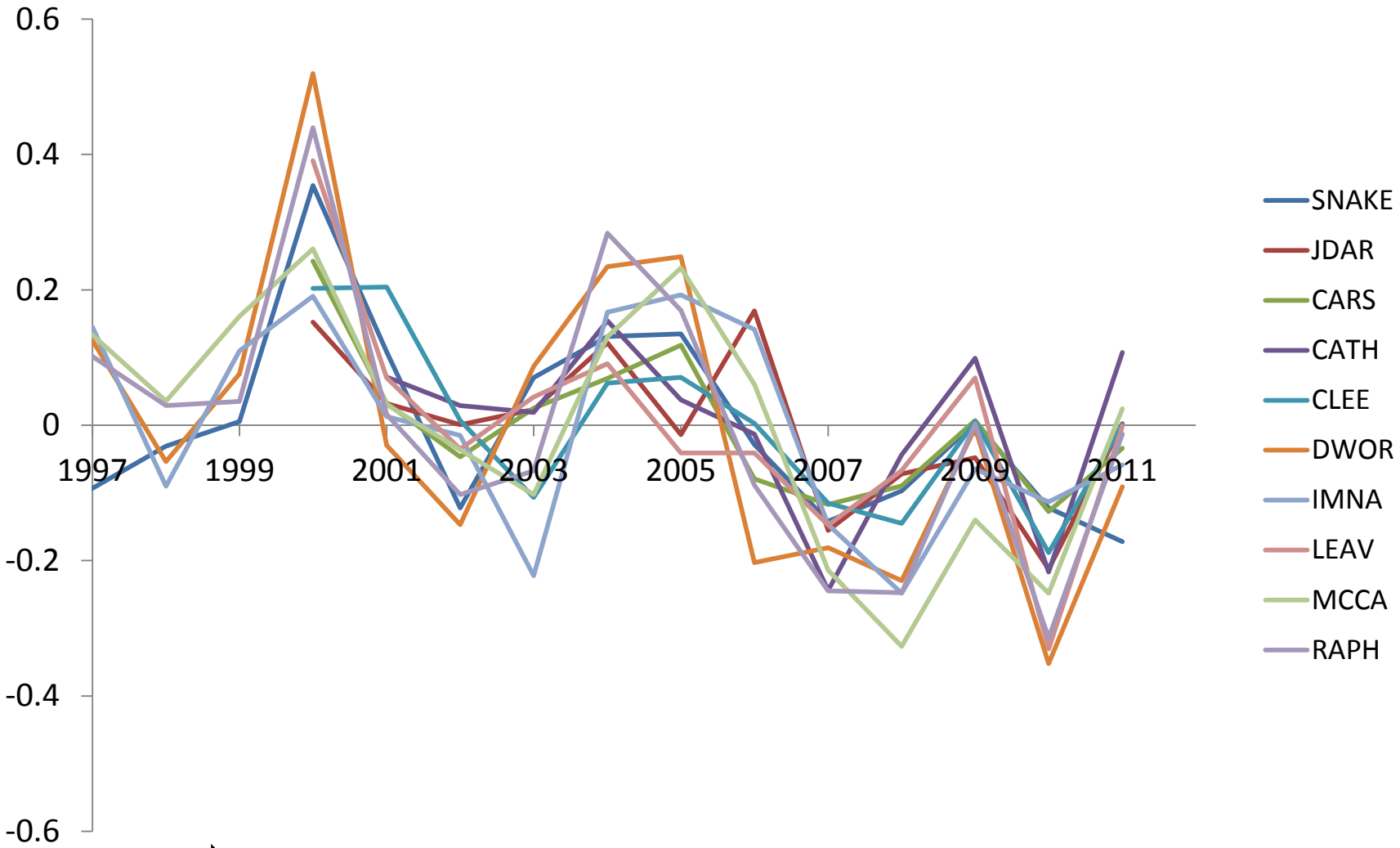
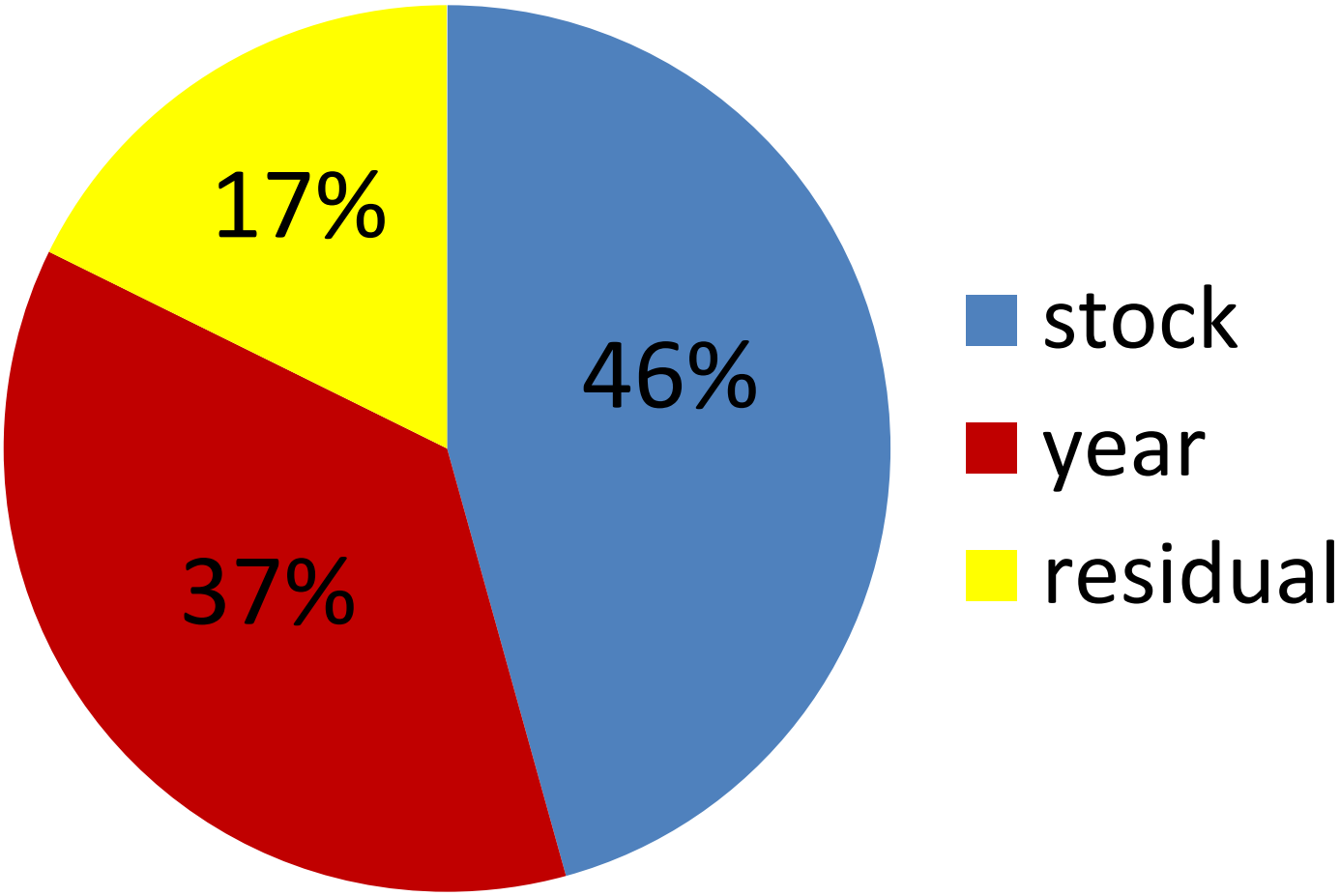


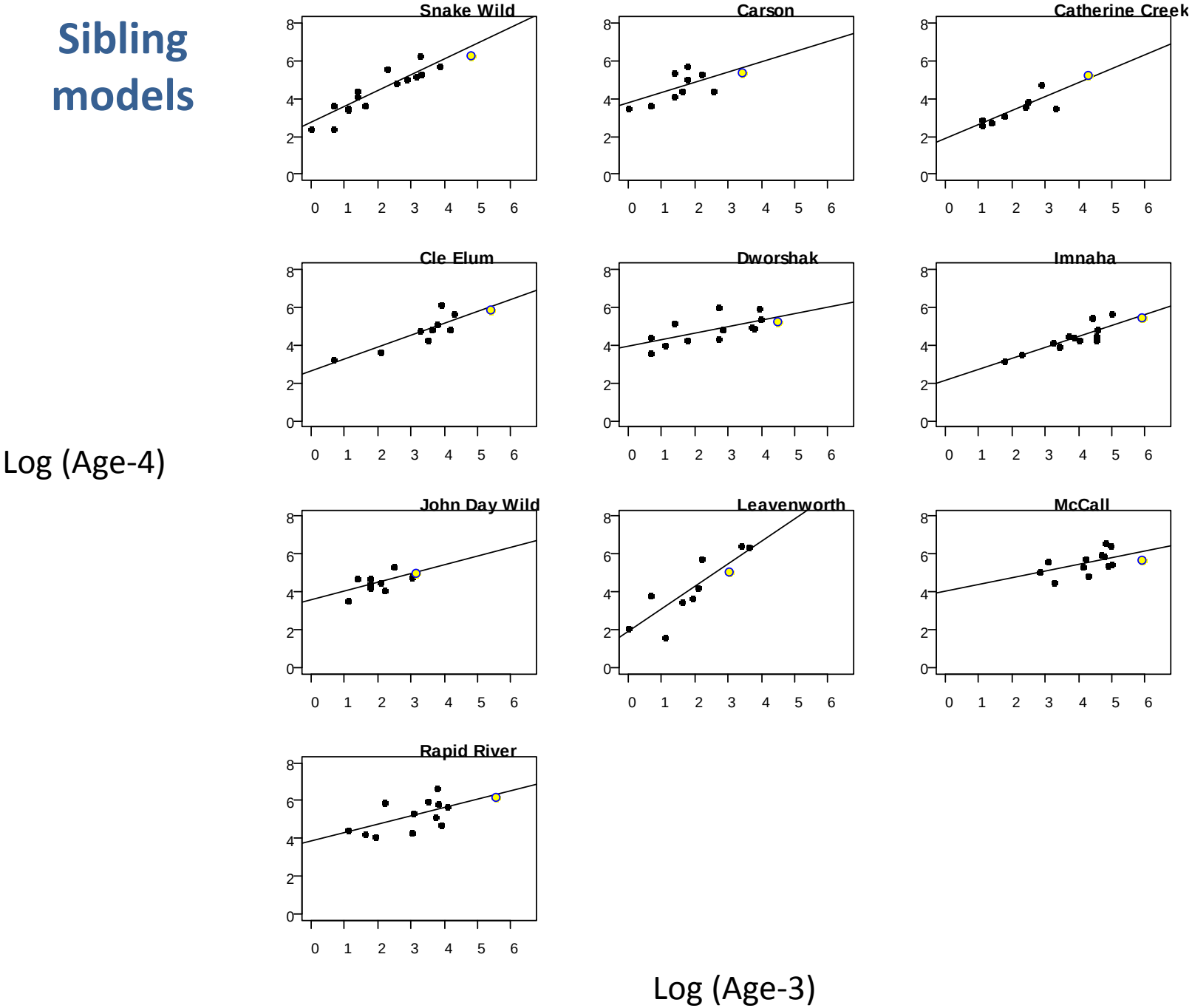
Shared temporal patterns in mean age across stocks

Variation in mean age

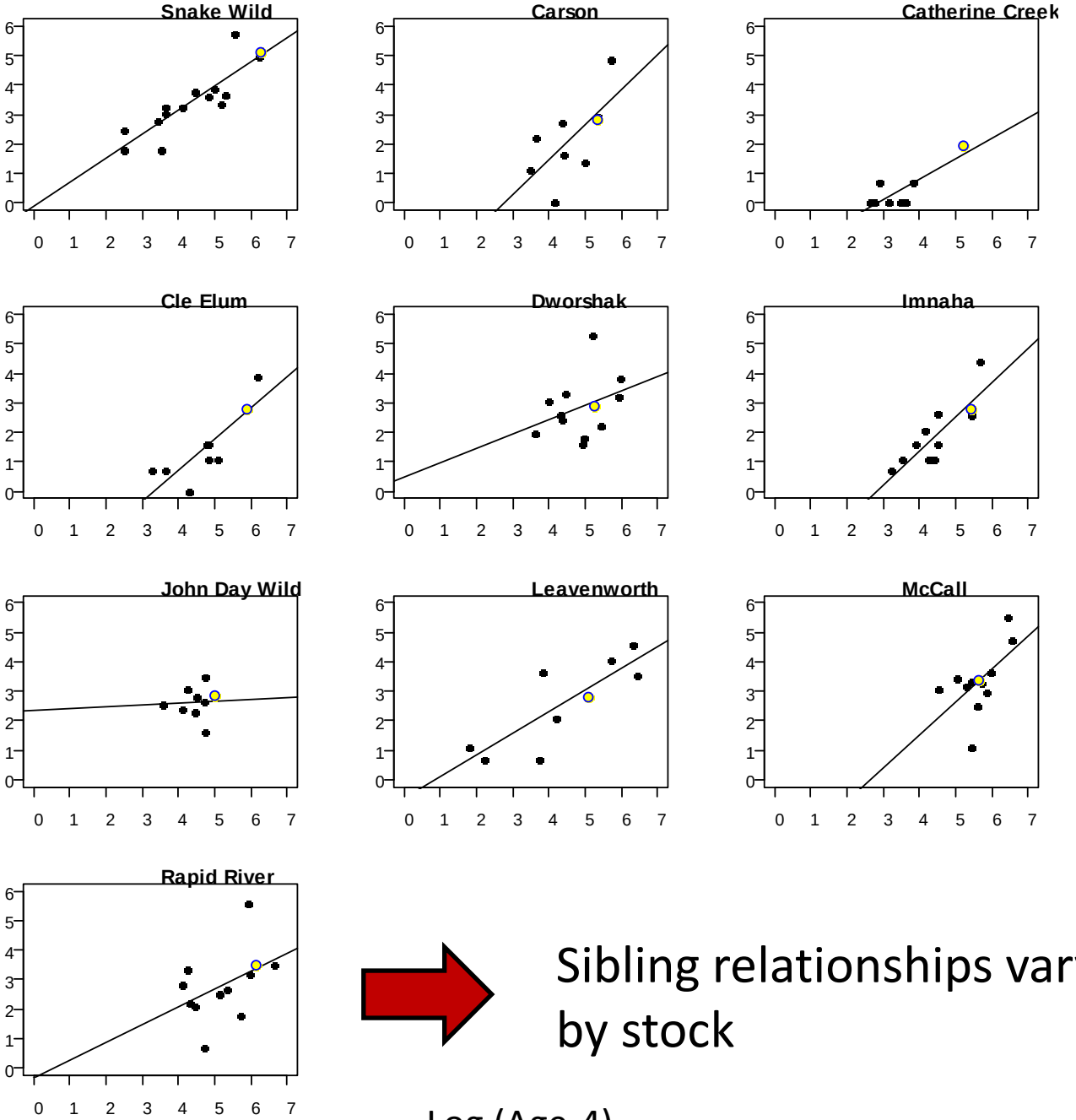


wright photography

Sibling models



Sibling relationships



Log (Age-5)

Log (Age-4)

Sibling relationships vary by stock

Kalman Filter sibling models

Standard sibling model:

$$\text{Log (Age-4)} = a + b * \text{Log (Age-3)}$$

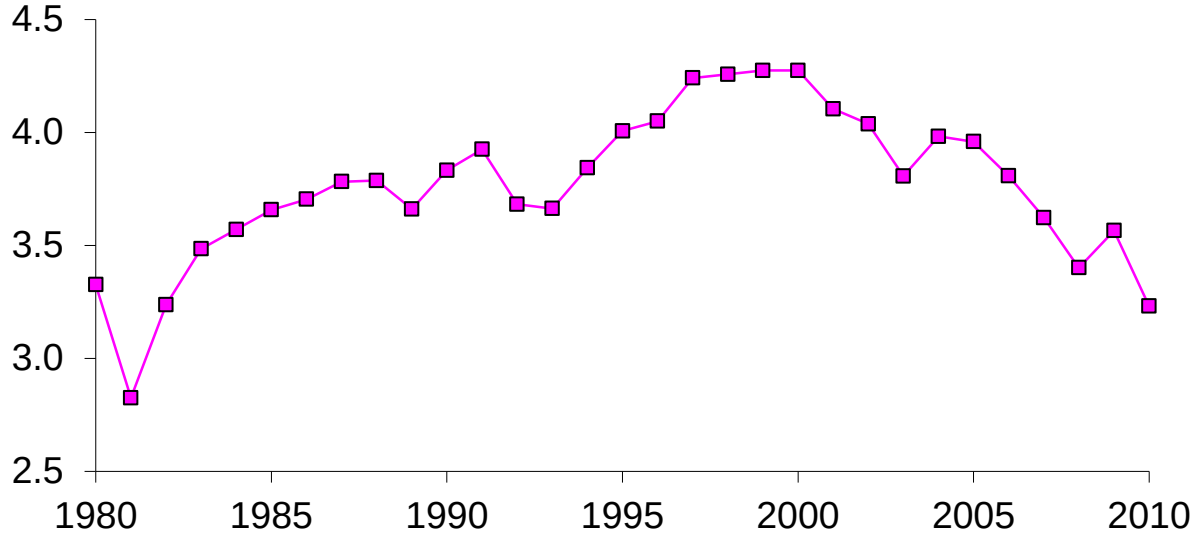
Kalman Filter sibling model:

$$\text{Log (Age-4)} = a_t + b * \text{Log (Age-3)}$$

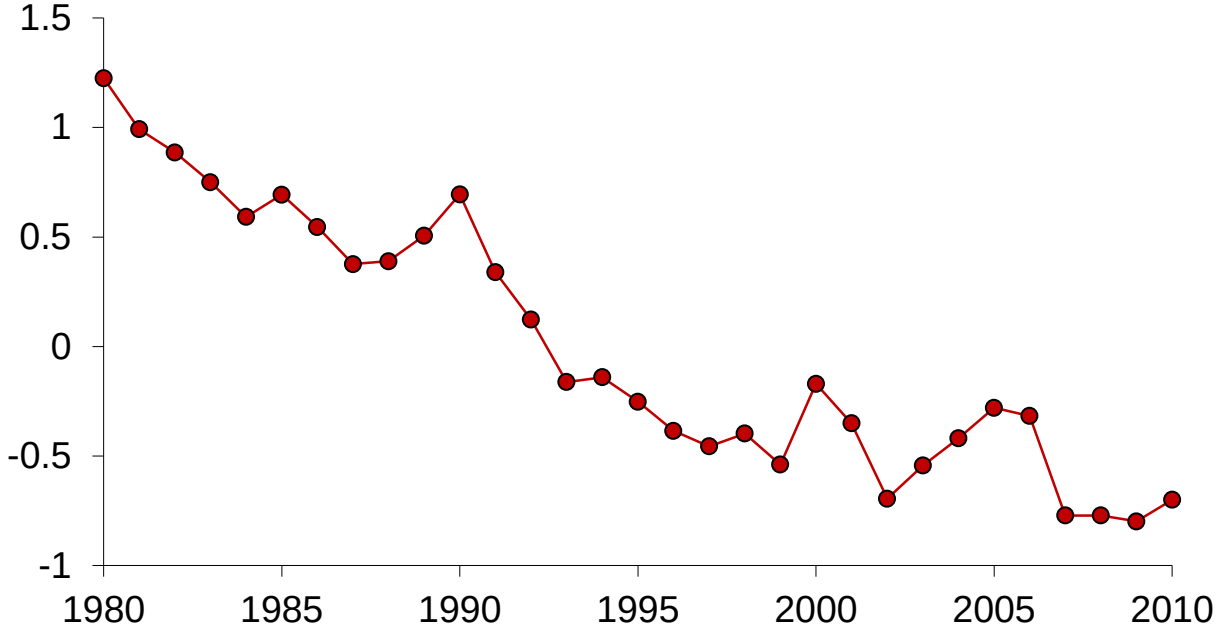
$$a_t = a_{t-1} + e_i$$

Kalman Filter sibling models

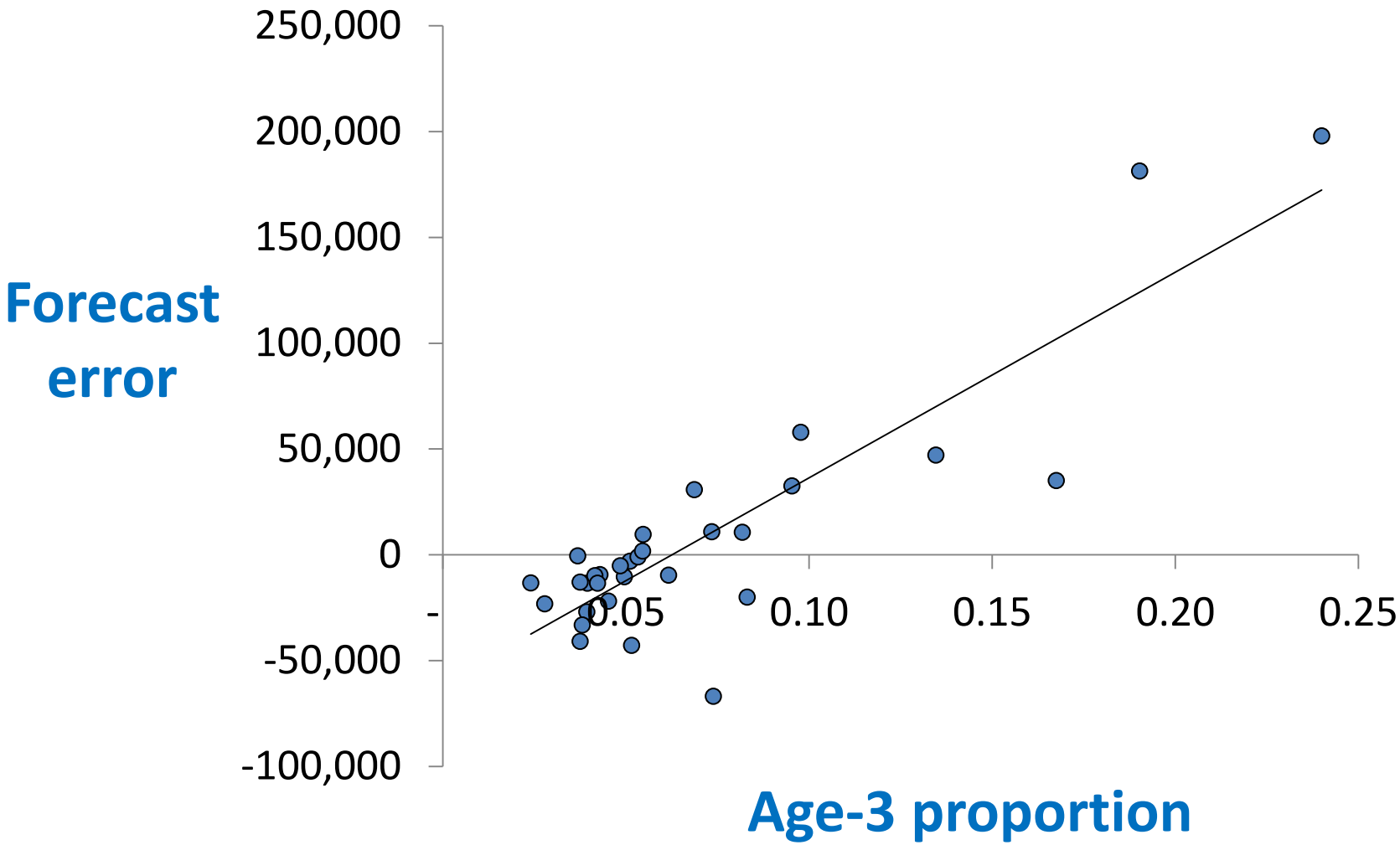
Age-4 ~ Age-3



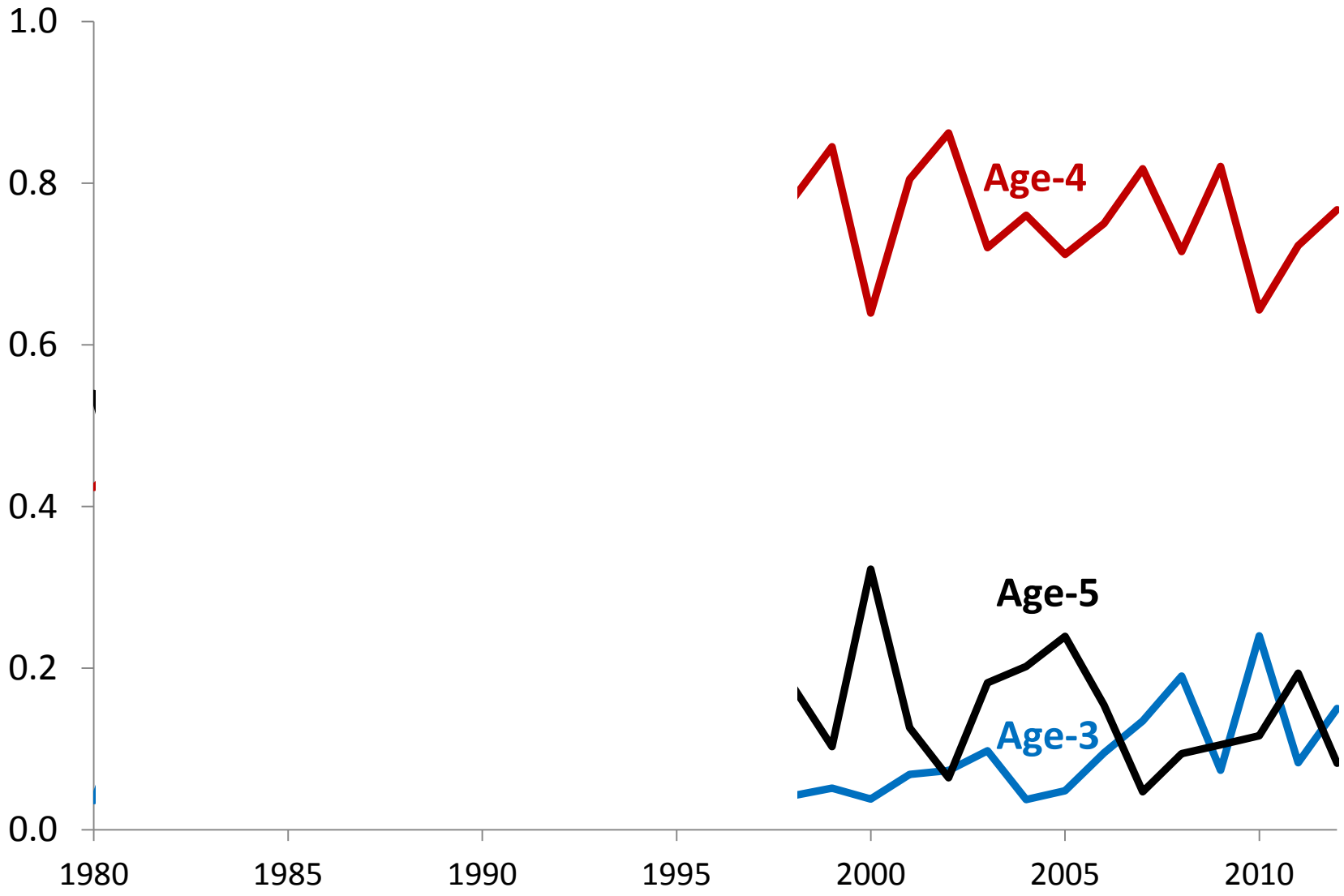
Age-5 ~ Age-4



Effects of variable jacking rates



Longer-term trends



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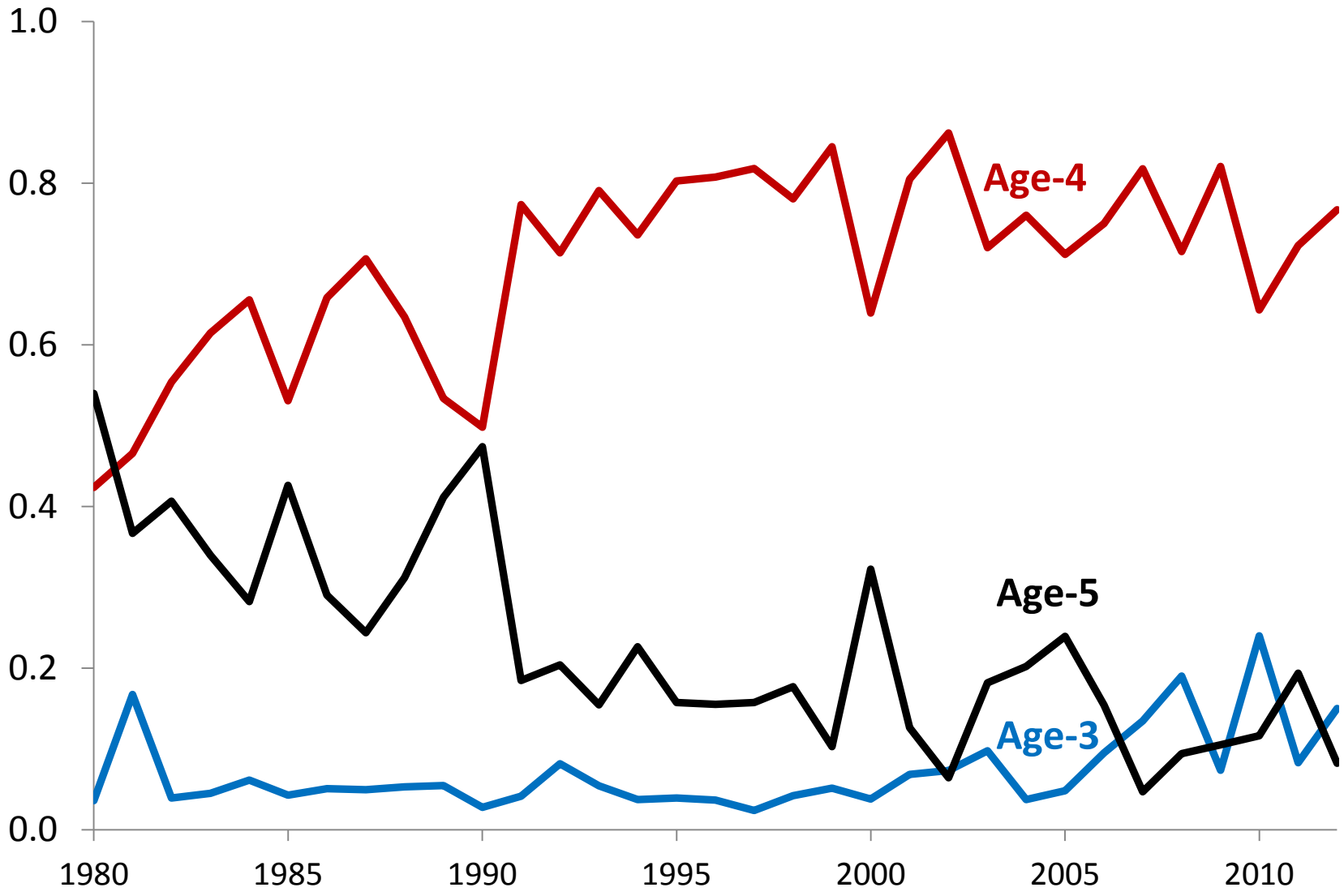
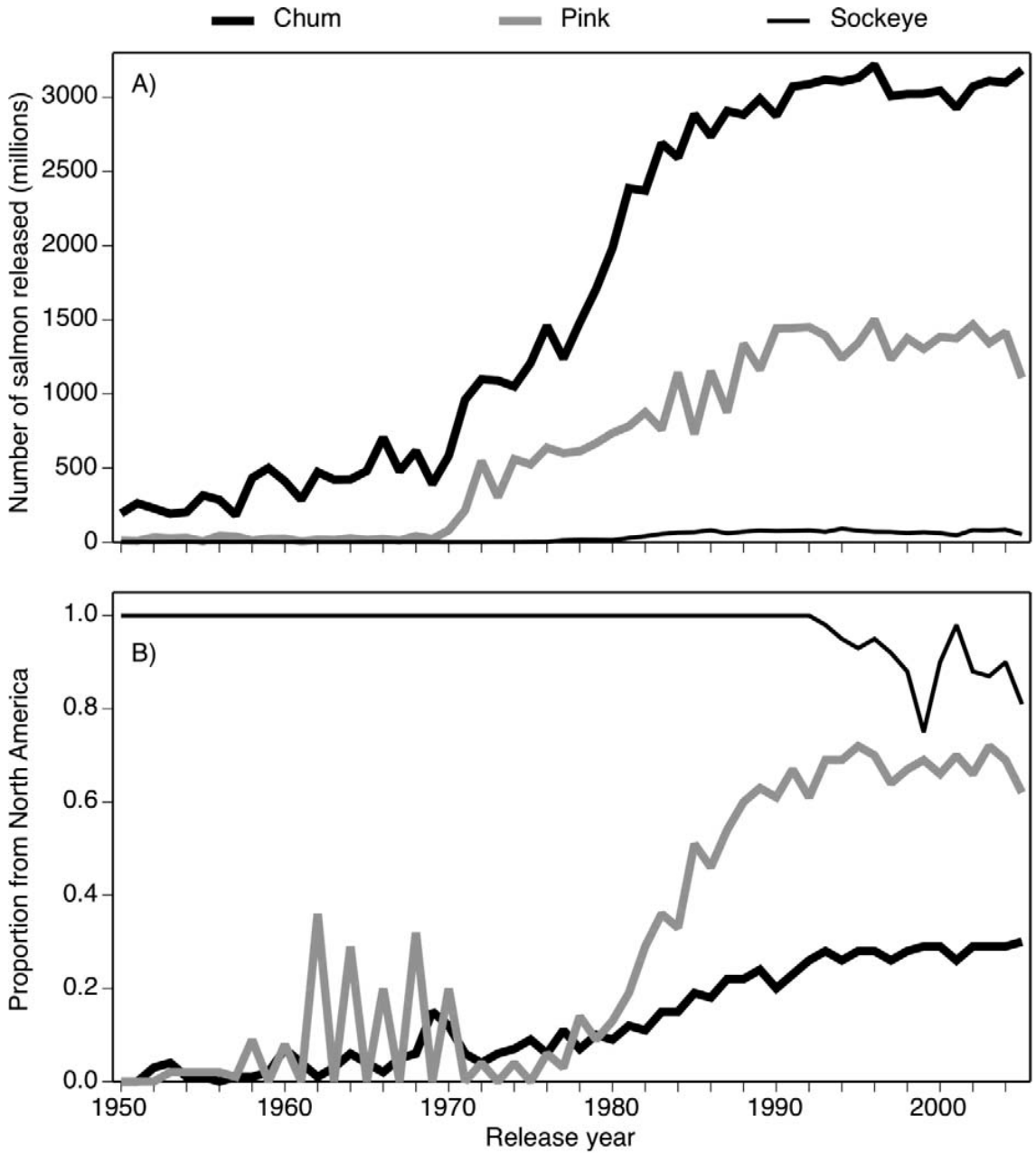


Out-of-basin factors?

Ruggerone et al. 2010



Conclusions and future directions…

Understanding age at mature is critically important

Large stock effects and shared temporal effects

Consider stock-specific forecasts

Investigate shared temporal effects (time & place)

Evaluate hypotheses against empirical data

Interested in collaborating! (long-term time series of similar data)