From divergence to convergence in sex differentials in adult mortality in developed countries

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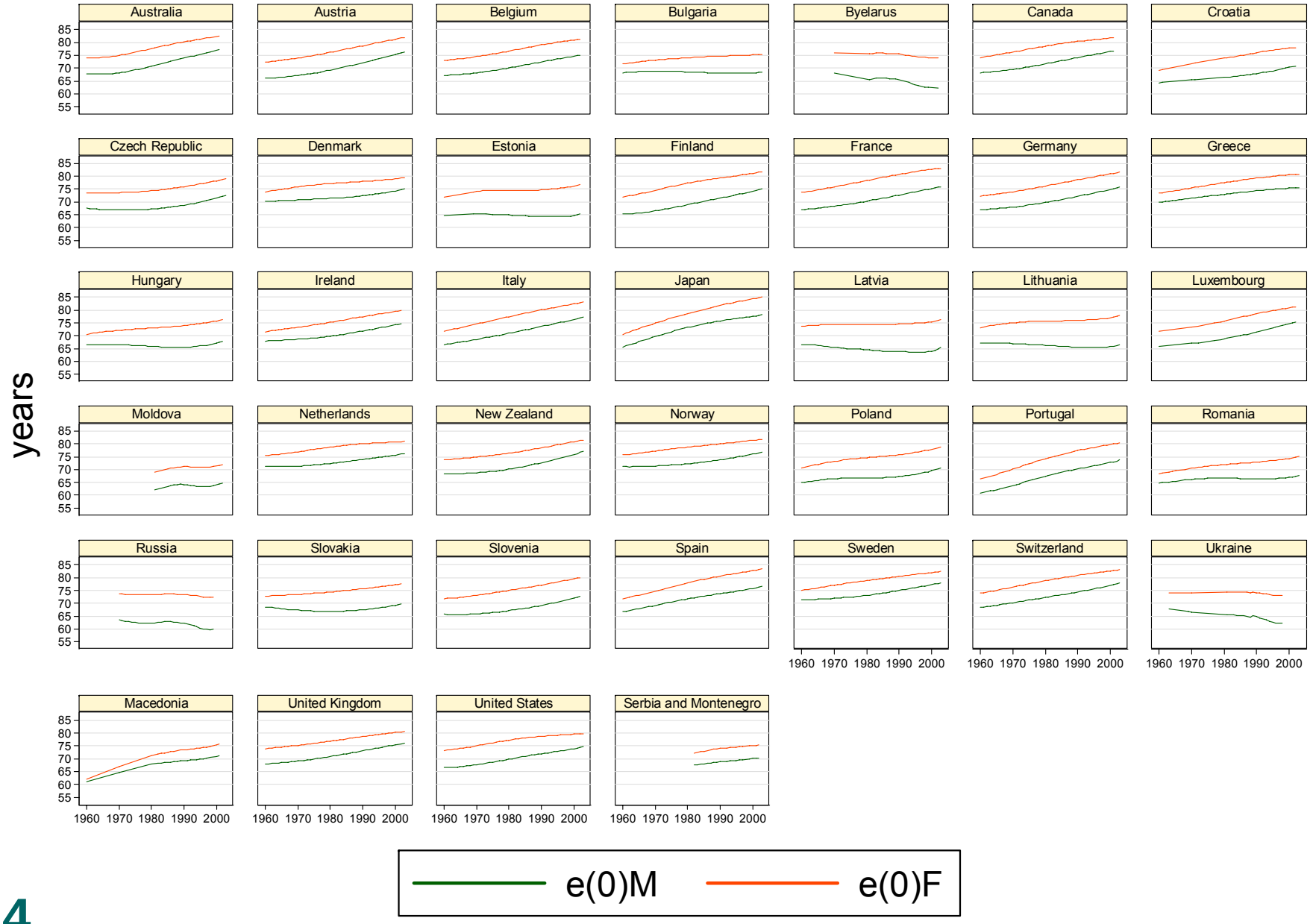
Research questions

- Recent decline of sex differentials in life expectancy at birth and at age 30 and 60
  - What age groups are most responsible for the recent reduction of sex differentials in life expectancy at birth
  - What factor explains the most the reversal in historical trends

Background

- Most gains in in life expectancy have been concentrated in recent decades among adults and especially among elderly.
- Both men and women have been experiencing greater survival at all ages. But, while the difference in adult survival was relatively small when mortality was high, progress in adult survival throughout the past century have been different between genders.
- The fact that women have almost consistently been experiencing faster improvements than men in gains of life expectancy has led to an increasingly divergent path.
- Model life tables (e.g., Coale and Demeny) and more recent mortality projection models built using cross-sectional time series of mortality rates by sex and ages (e.g., Lee-Carter) often extrapolates these past trends in the future.
- In most cases, the long term trends obtained by projecting each sex independently lead to implausible large differences between sexes – especially in the light of recent trends experienced by most countries with the highest life expectancies.

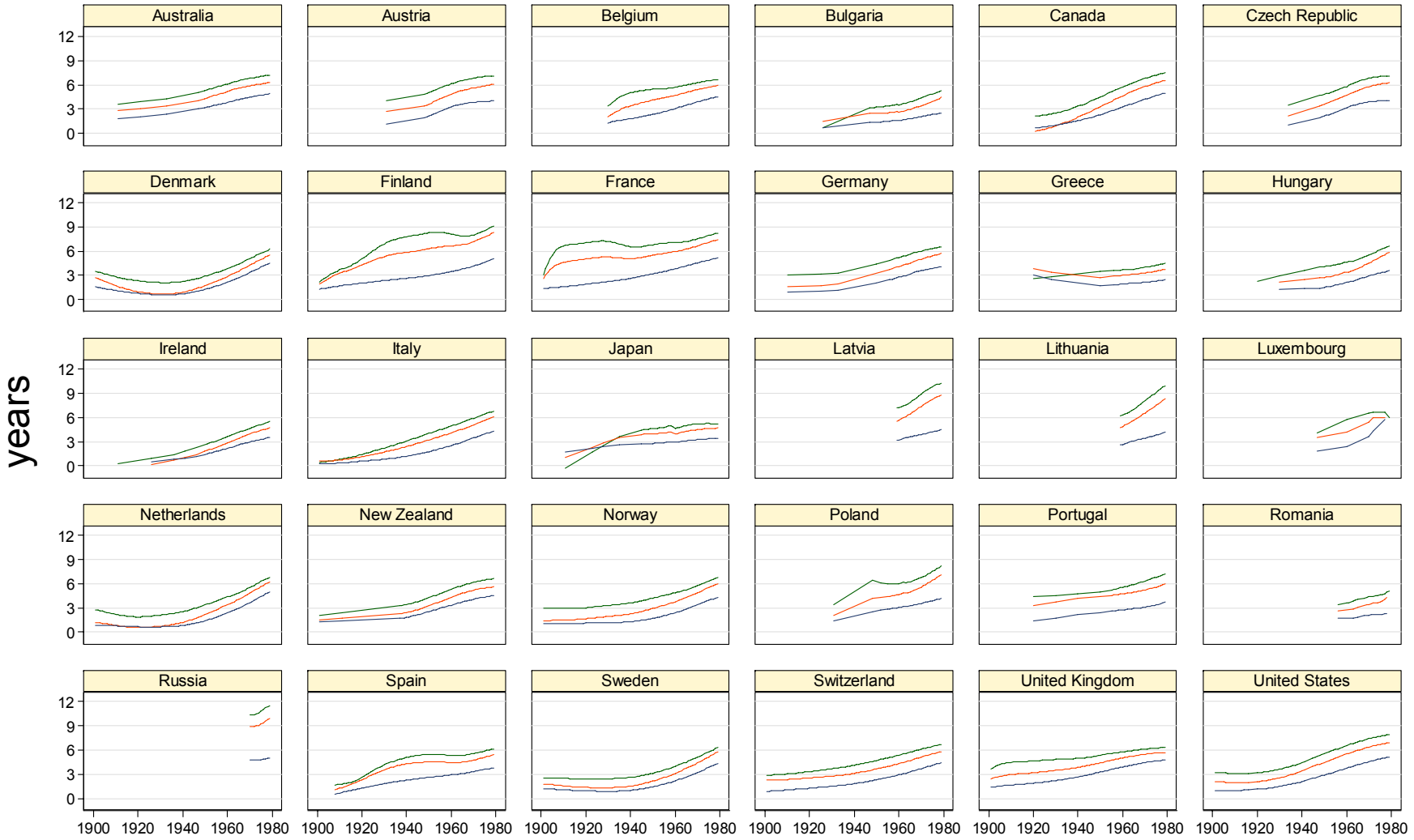
Trends in life expectancy at birth by sex



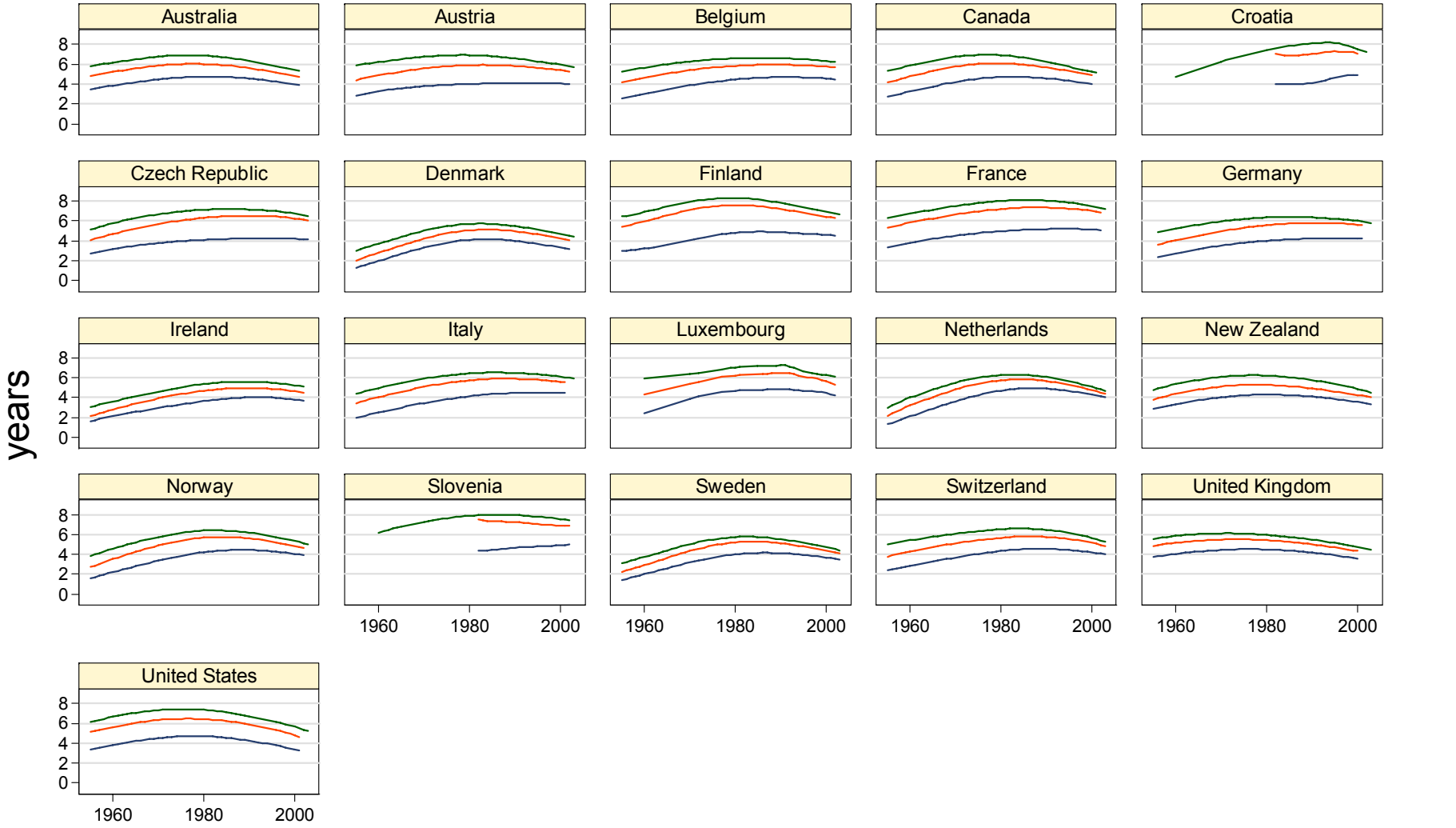
Trends in sex differentials

1. Secular Divergence: sex differentials in life expectancies have been increasing in all developed nations from the early XXth century until the 1980s.
2. Convergence: since the 1980s, trend reversal in most developed countries: the difference in adult survival between men and women has been decreasing toward levels experienced in the 1950s.
3. Exceptions: Eastern Europe and economies in transition as well as Japan, Spain, Portugal and Greece: sex differentials in life expectancies continue to increase.

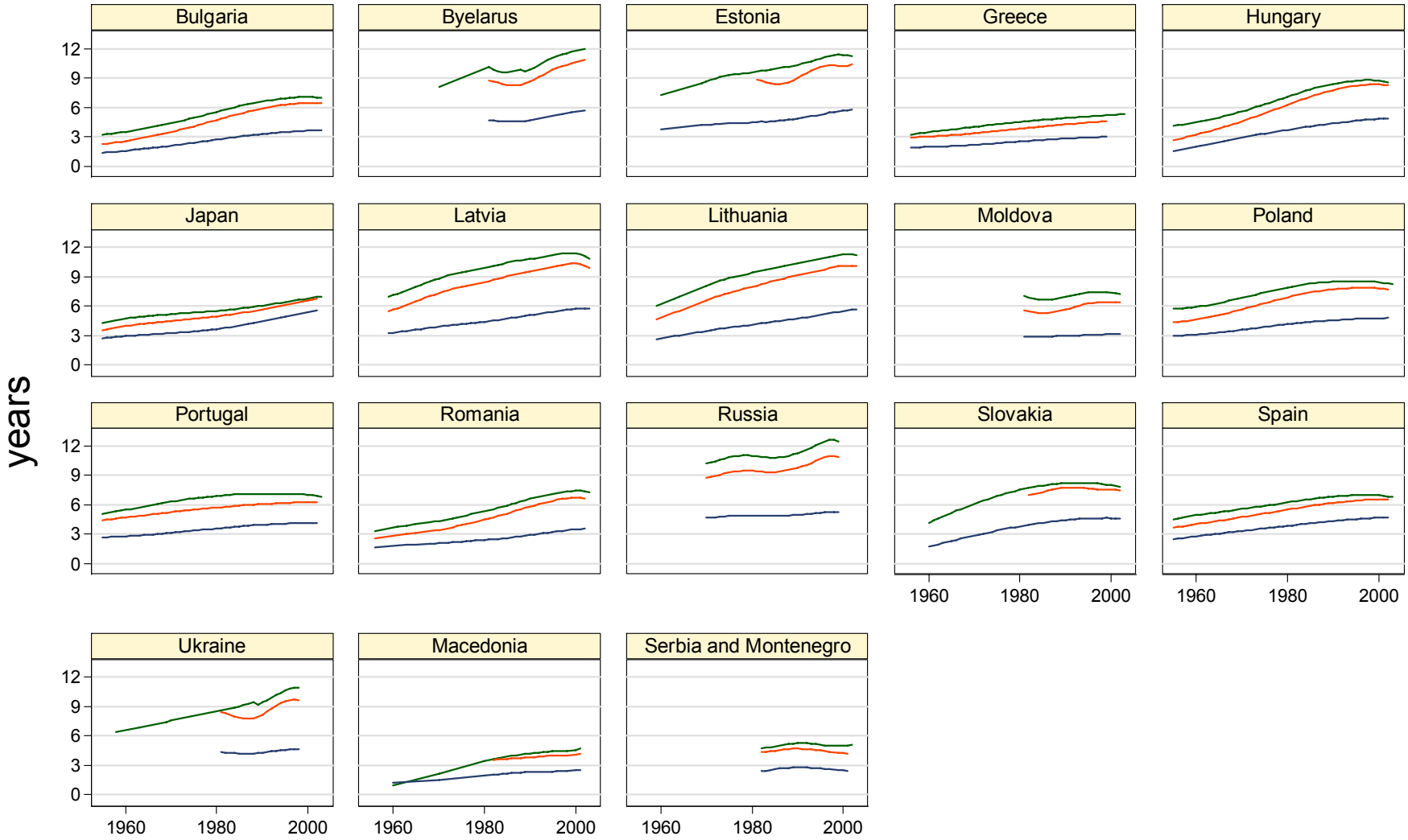
1. Divergence: secular increase in sex differential in e_x



2. Convergence: 1980-2005 decrease in sex differential in e_x



3. Exceptions: continuing increase in sex differential in e_x



Trends in Sex Differential in e_{30}

Country	Period	Observed female-male difference in life expectancy at age 30 (in years)								
		< 1850	1850-1899	1900-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000 &+
Australia		-	-	3.2	4.7	5.7	6.1	6.0	5.4	4.7
Austria		-	-	3.2	4.2	5.3	5.9	6.0	5.8	5.3
Belgium		-	-	3.4	4.1	5.2	5.7	6.0	6.0	5.7
Bulgaria		-	-	2.3	2.4	2.9	3.9	5.4	6.5	6.3
Byelarus		-	-	-	-	-	-	8.3	9.7	10.9
Canada		-	-	1.4	4.0	5.3	6.2	6.0	5.5	4.7
Croatia		-	-	-	-	-	-	6.8	7.3	6.7
Czech Republic		-	-	3.0	4.1	5.3	6.1	6.5	6.6	6.1
Denmark		1.7	1.7	1.0	1.9	3.5	4.9	5.3	4.7	4.2
Estonia		-	-	-	-	-	-	8.3	10.0	10.3
Finland		-	1.9	4.8	5.6	6.4	7.8	7.6	6.9	6.3
France		-	2.4	4.9	5.2	6.3	7.0	7.4	7.4	6.9
Germany		-	-	1.6	3.8	4.6	5.4	5.8	5.9	5.5
Greece		-	-	3.5	2.9	3.1	3.5	4.1	4.4	-
Hungary		-	-	2.5	2.9	3.8	5.2	7.1	8.5	8.0
Ireland		-	-	0.8	2.2	3.4	4.4	5.1	5.0	4.5
Italy		-	0.1	1.5	3.3	4.6	5.5	6.0	5.9	5.5
Japan		-	-	4.0	3.5	4.3	4.6	5.2	6.0	6.6
Latvia		-	-	-	5.4	6.4	8.1	8.5	10.5	10.0
Lithuania		-	-	-	4.7	5.6	7.4	8.3	9.9	10.1
Luxembourg		-	-	3.5	-	4.2	5.8	6.8	6.1	5.4
Macedonia		-	-	-	-	-	-	3.7	4.0	4.2
Moldova		-	-	-	-	-	-	5.3	6.2	6.4
Netherlands		-	0.9	0.8	2.1	4.1	5.5	6.2	5.4	4.6
New Zealand		-	-	2.4	3.7	4.9	5.5	5.3	4.7	4.1
Norway		1.9	1.5	1.8	2.8	4.3	5.5	6.0	5.4	4.7
Poland		-	-	3.2	4.4	4.9	6.3	7.4	8.0	7.6
Portugal		-	-	3.7	4.6	5.0	5.5	5.9	6.3	6.1
Romania		-	-	-	2.6	3.1	3.7	4.9	6.6	6.5
Russia		-	-	-	-	-	9.3	9.2	10.7	-
Serbia and Montenegro		-	-	-	-	-	-	4.5	4.6	4.3
Slovakia		-	-	-	-	-	-	7.4	7.7	7.5
Slovenia		-	-	-	-	-	-	7.3	7.1	7.0
Spain		-	-	3.4	3.8	4.4	5.1	5.8	6.6	6.4
Sweden		2.4	2.3	1.4	2.2	3.5	5.1	5.5	4.9	4.2
Switzerland		-	1.8	2.6	3.7	4.8	5.4	5.9	5.7	5.0
Ukraine		-	-	-	-	-	-	7.9	9.3	-
United Kingdom		0.8	1.9	3.3	4.8	5.4	5.6	5.3	4.8	4.3
United States		-	-	2.4	5.1	6.1	6.6	6.3	5.6	4.7

Hypotheses explaining the reduction in sex differentials

- Women's gains in life expectancy has been slowing down
- Men have been making faster progress in survival than women
- Limits to divergence in sex differentials exist
- A convergence toward a universal model of sex differentials is happening at some stage of the epidemiological transition

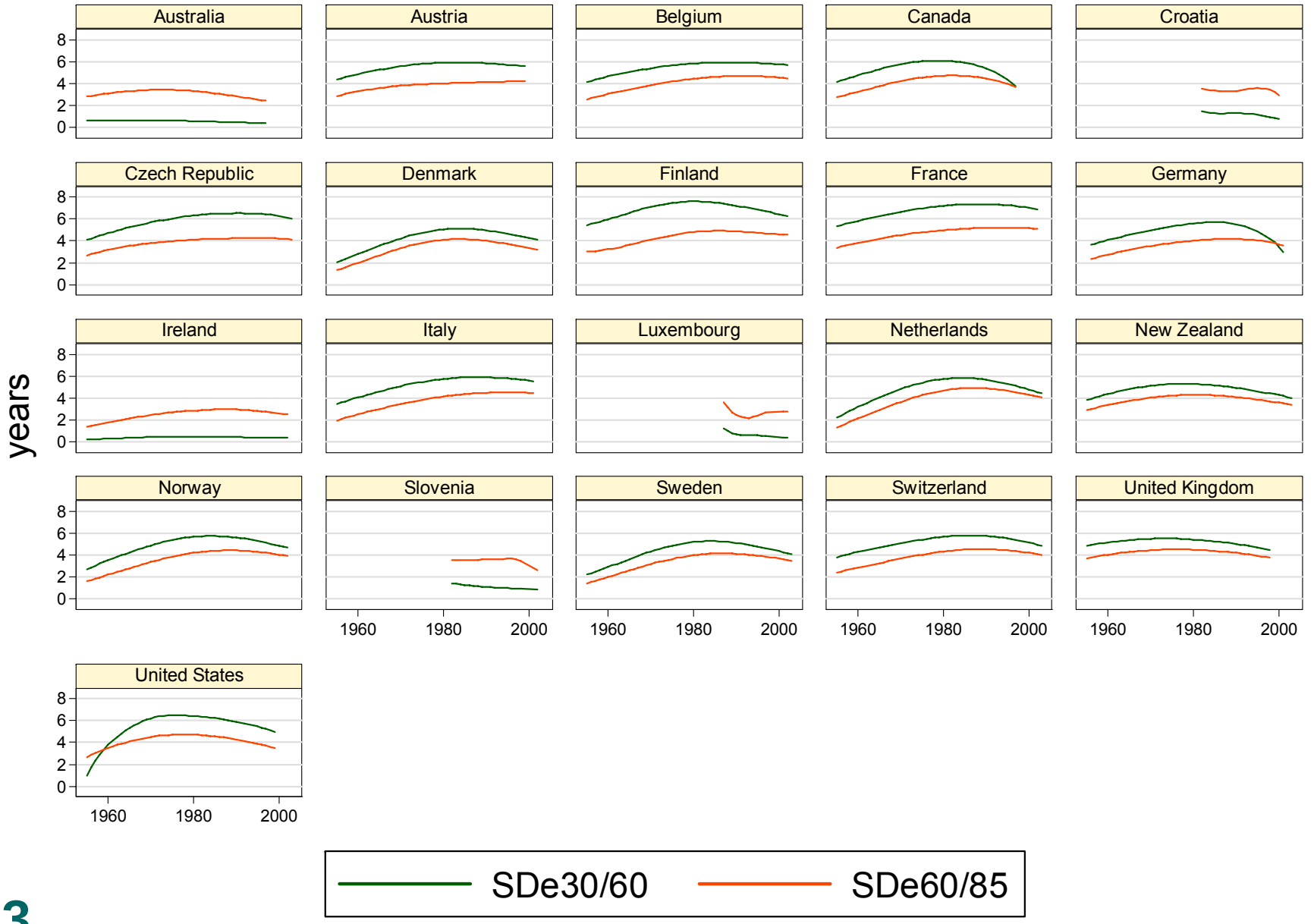
Data sources

- 39 developed countries with annual life tables for all causes of death spanning from 1950 to 2004 (n=2858)
- **Human Mortality Database**, sponsored by the University of California, Berkeley, and the Max Planck Institute for Demographic Research (http://www.mortality.org): 2157 life tables
- **World Health Organization Mortality Database** (http://www.who.int/whosis/): 472 life tables
- **United Nations Statistics Division Demographic Yearbook database** (http://unstats.un.org): 97 life tables
- **Eurostat database** (http://epp.eurostat.cec.eu.int): 132 life tables

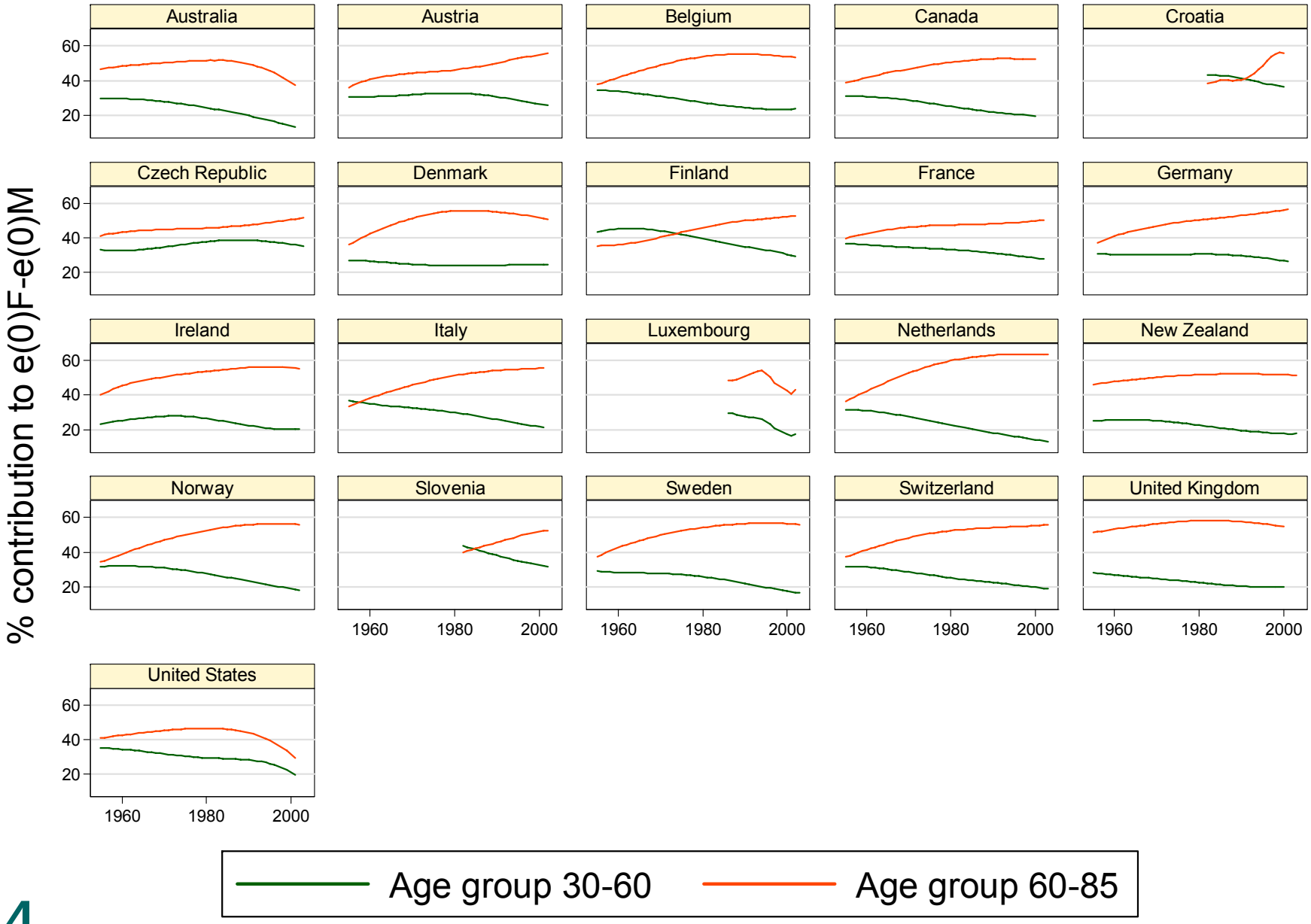
Outcomes

- sex differentials in life expectancy at age 30 for age group 30-60($SDe_{30/60}$) and at age 60 for age group 60-85 ($SDe_{60/85}$)
  - $SDe_{30/60} = e^{f}_{30/60} - e^{m}_{30/60}$ with $e_{30/60} = (T_{30}-T_{60}) / l_{30}$
  - $SDe_{60/85} = e^{f}_{60/85} - e^{m}_{60/85}$ with $e_{60/85} = (T_{60}-T_{85}) / l_{60}$
- absolute and relative contribution of sex differentials in mortality in age groups 30-60 ($\Delta SDe_{30/60}$) and 60-85 ($\Delta SDe_{60/85}$) to sex differentials in life expectancy at birth

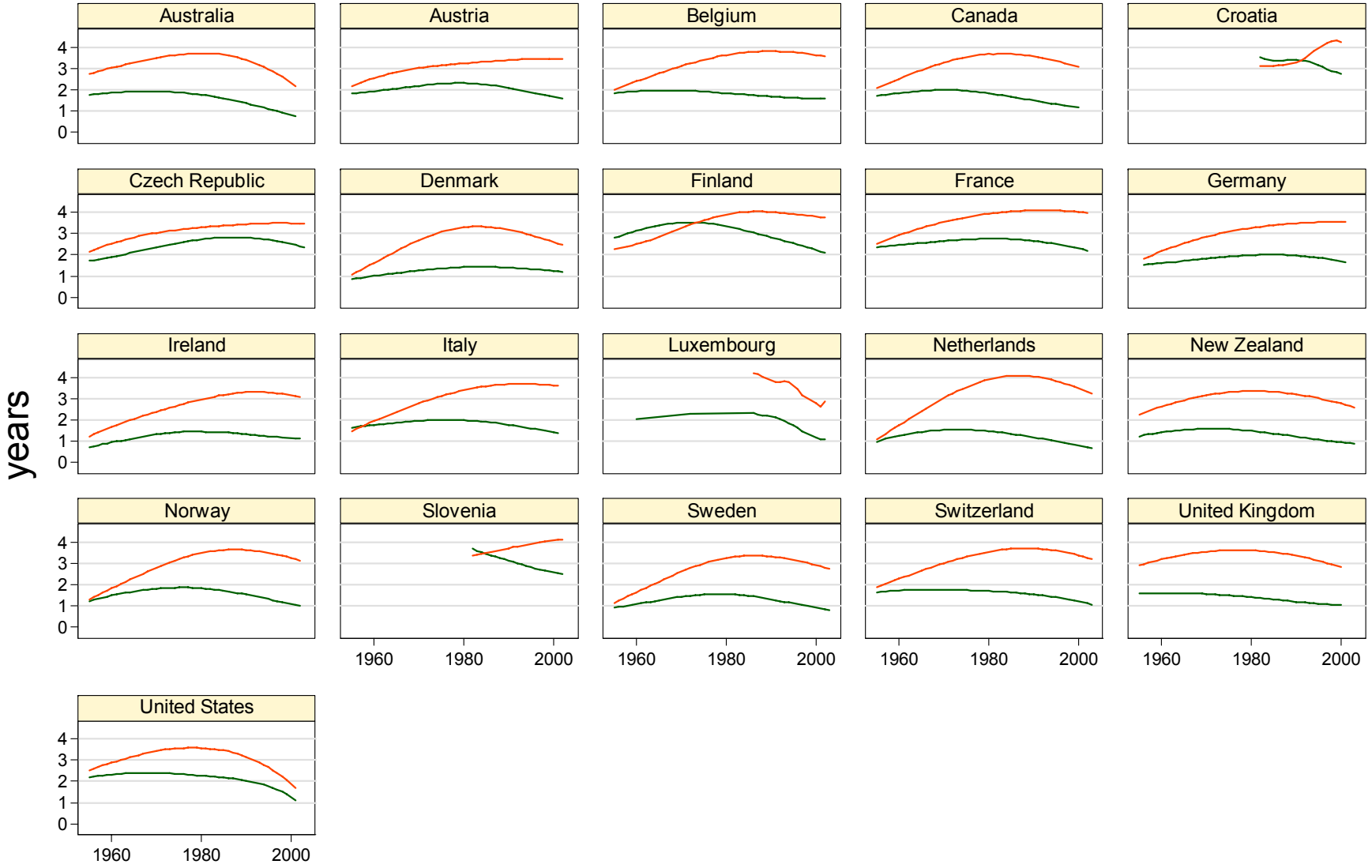
1. Convergence: recent decrease in sex differentials in $e_{30/60}$ and $e_{60/85}$



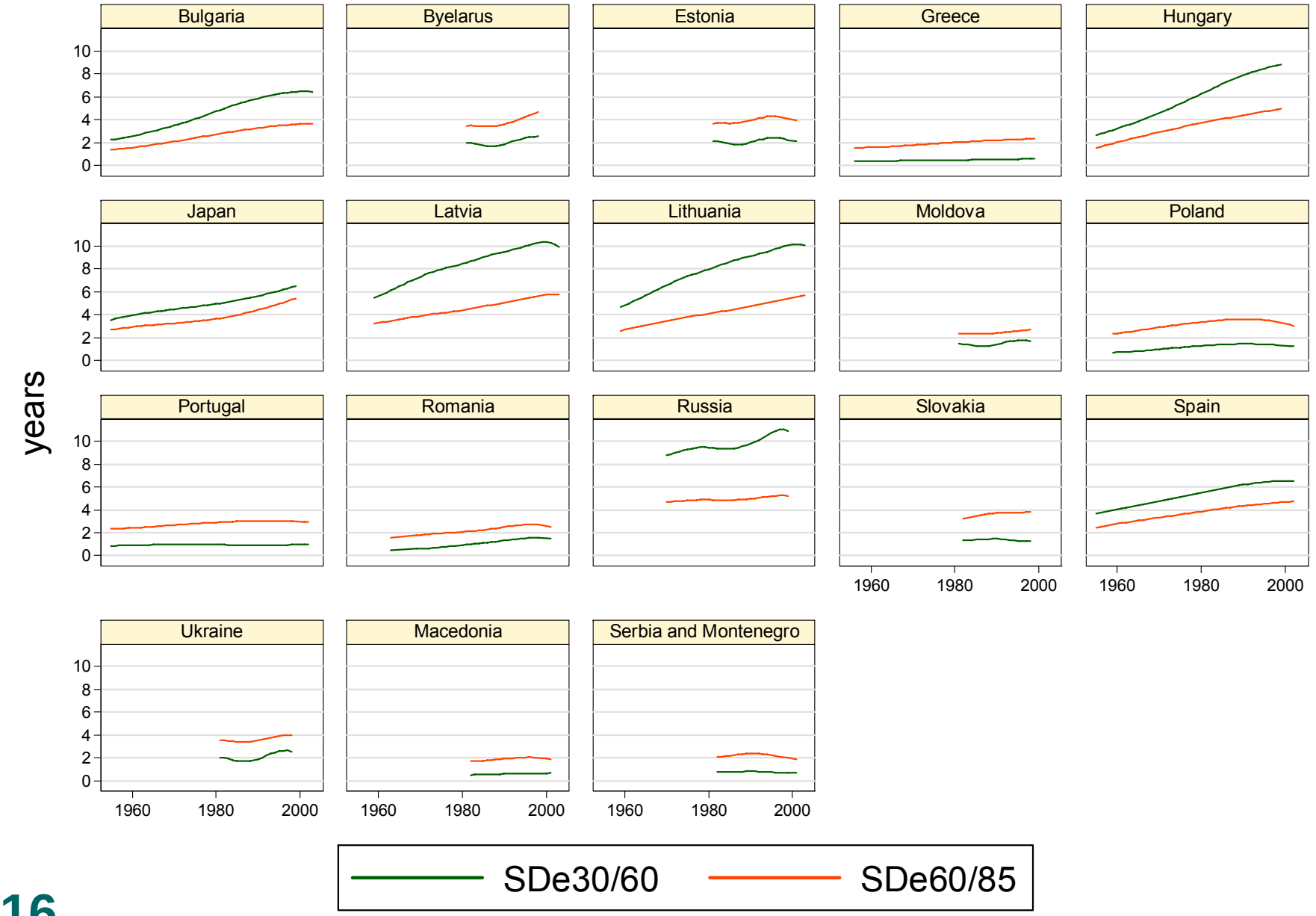
2a. Age groups contribution (%) to reduction of sex differentials in e(0)



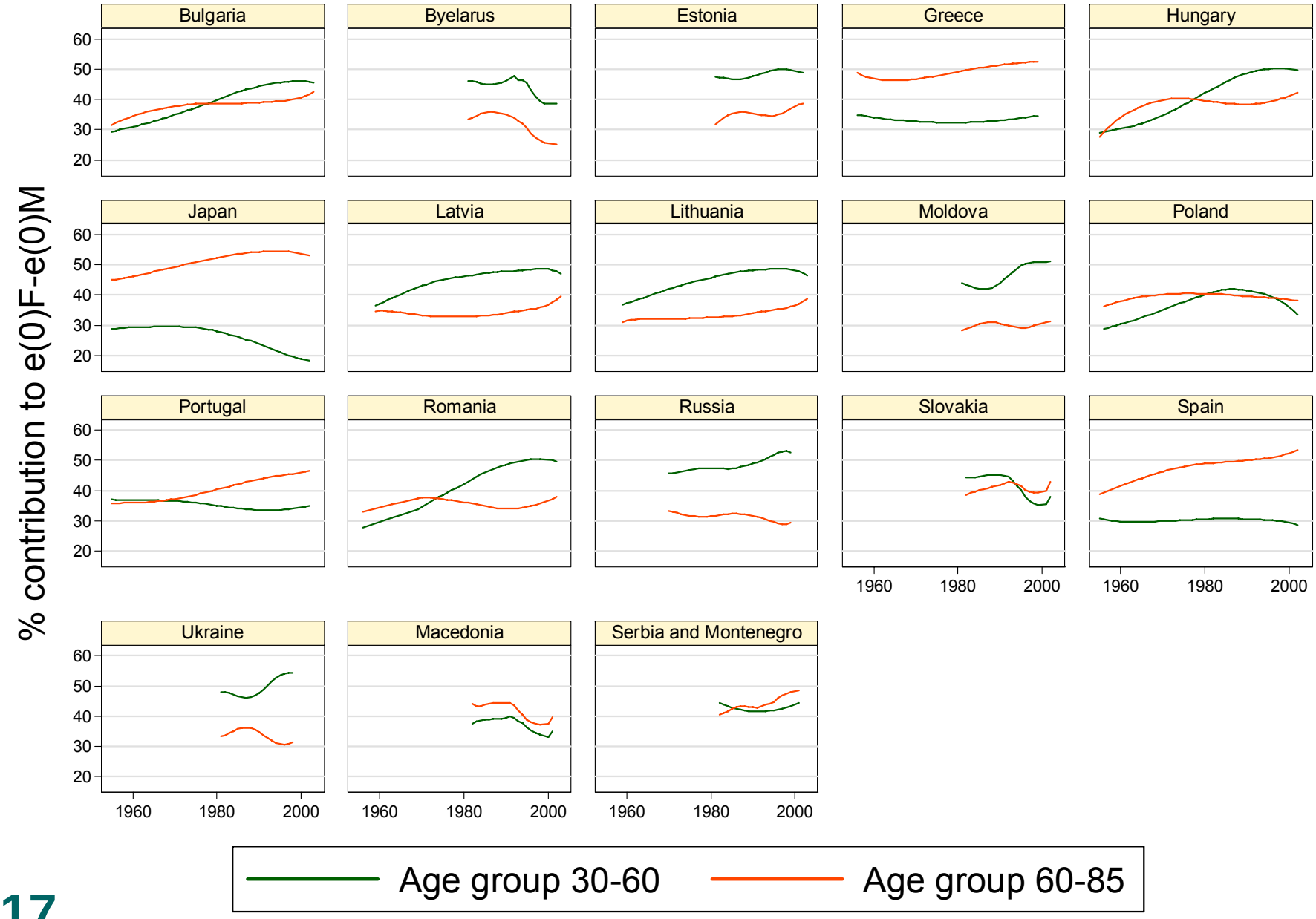
2b. Age groups contribution to reduction of sex differentials in e(0)



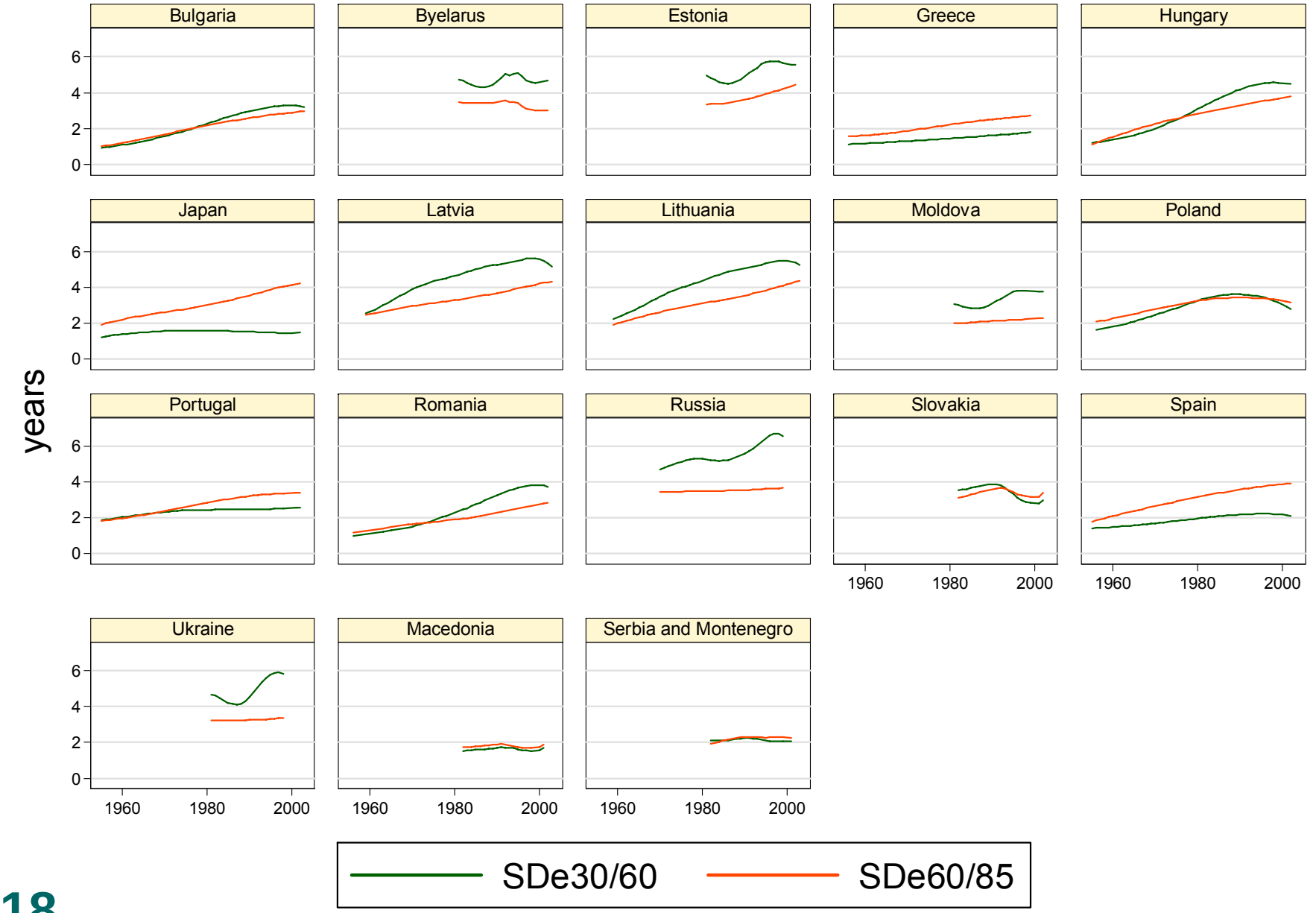
3. Divergence and Convergence in sex differential in $e_{30/60}$ and $e_{60/85}$



4a. Age groups contribution (%) to increase of sex differentials in e(0)



4b. Age groups contribution to increase of sex differentials in e(0)



Statistical Modeling

- Multivariate analysis of variations over time (t) of sex differential in life expectancy at birth based on female e(0) and sex differentials in e(0) decomposed by age groups for country (i):
- *Model 1 with Trend dummy:*

$$e^m(0)_{it} = \beta_0 + \beta_1 e^f(0)_{it} + \beta_2 \Delta SDe(15/30)_{it} + \beta_3 \Delta SDe(30/60)_{it} + \beta_4 \Delta SDe(60/85)_{it} + \beta_5 \Delta SDe(85/100)_{it} + \beta_6 trend_i + u_{it} + e_{it}$$

- *Model 2 with Trend and Region (1-6) dummies:*

$$e^m(0)_{it} = \beta_0 + \beta_1 e^f(0)_{it} + \beta_2 \Delta SDe(15/30)_{it} + \beta_3 \Delta SDe(30/60)_{it} + \beta_4 \Delta SDe(60/85)_{it} + \beta_5 \Delta SDe(85/100)_{it} + \beta_6 trend_i + \beta_7 region2_i + \ldots + \beta_{11} region6_i + u_{it} + e_{it}$$

Results

Coefficients	Model 1	Model 2
exF(0)	0.9678**	0.9675**
SDe(0/15)	(-)	(-)
SDe(15/30)	-0.9189**	-0.9560**
SDe(30/60)	-0.9885**	-0.9868**
SDe(60/85)	-0.5911**	-0.6045**
SDe(85/100)	-0.2231	-0.1676
Trend (diverging vs converging)	0.0351	0.0550
constant	0.5023	0.6057
(Northern Europe)		(-)
Western Europe		-0.1127+
Eastern Europe		-0.1453*
Southern Europe		0.1667**
Asia - Australia/NZ		-0.0502
North America		-0.2114*
sigma_u	0.1023	0.0808
sigma_e	0.3861	0.3861
rho	0.0656	0.0419
R-sq: within	0.9792	0.9790
R-sq: between	0.9908	0.9927
R-sq: overall	0.9846	0.9854

Discussion

- Many countries are at different stages of their epidemiological transition, and the reduction of the sex differentials is caused by both a deceleration/leveling of female survival and an acceleration of male survival.
- The reduction of the gender gap in many instances reflects a reduction in exogenous causes of male mortality (e.g., life style, health behaviors, etc.)
- The convergence towards a common path for both sexes suggests that the remaining sex differential is increasingly explained by irreducible biological sex differences