Rural exodus and fertility at the time of industrialization

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Introduction

- Rural exodus $\Rightarrow$ urbanization in Europe but no estimation of its impact on the take-off to sustained economic growth
- We fill that gap:
  - UGT capturing the interactions between urbanization, demographic transition and take-off to sustained economic growth
  - Structural estimation of the impact of the Rural Exodus (RE) for Denmark and Sweden
  - Compare this impact to that of mortality reductions and agricultural revolution

Introduction

Main findings:

- RE as an important pre-requirement for the economic take-off, fertility transition and transition to mass education. More important than mortality and agricultural revolution
- A mechanism to reduce inequalities between areas.
- Quantitative results for Sweden:
  - Maintaining real migration costs constant between 1760 and 1960 would have delayed the take-off by more than one century
  - Mortality reductions have a negligible effect
  - Enclosure have delayed the take-off and impoverish the country in the long run

Outline of the presentation

1. Data
2. Model
3. Results
4. Historical experiments

Sources

Denmark:

- *Demographic side:* Treadway (1980), Matthiessen (1984), Johansen (2002), Lassen (1965) and own calculations using Statistiske Undersogelser, vol. 19. (Departement, 1966).
- *Economic side:* Johansen (1985) and own calculations, Flora (1983), Benavot and Riddle (1988)

Sweden:

- *Demographic side:* Historisk statstik for Sverige (Centralbyran, 1969), the Demographic Data Base on Swedish Historical Population Statistics (SHiPs- Demographic Data Base) offered by the Umea University, national statistic yearbooks and the Princeton European Fertility Project.
- *Economic side:* de la Croix et al. (2008), Swedish Historical National Accounts

Swedish and Danish historical data

Mortality

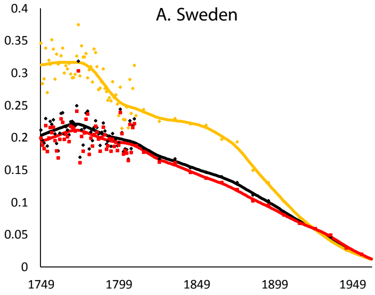


Figure: Infant mortality in cities (orange), countryside (red) and overall (black) Sweden 1749–1960 and Denmark 1840–1940.

Swedish and Danish historical data

Fertility

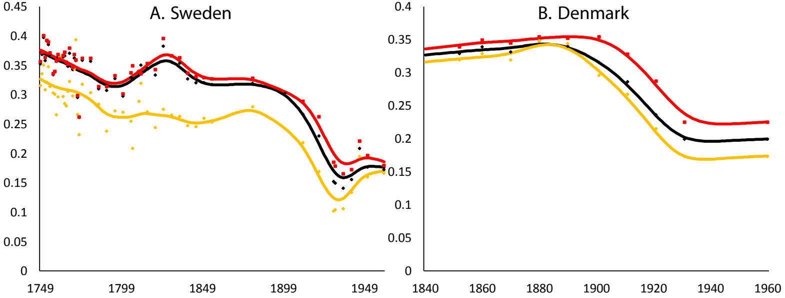


Figure: Coale's index in cities (orange), countryside (red) and overall (black) Sweden 1749–1960 and Denmark 1840–1960.

▸ Coale's Index

Swedish and Danish historical data

Population dynamics

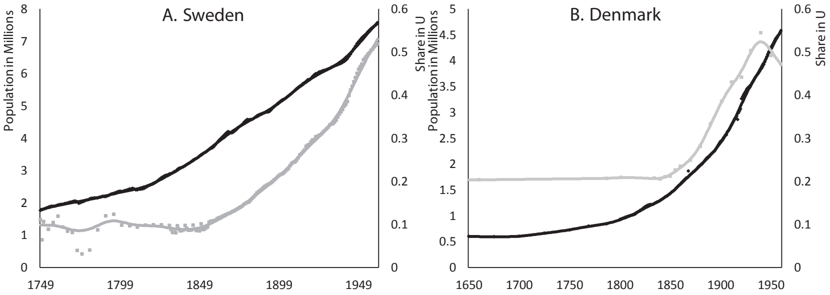


Figure: Total Population (black) and population share in cities (gray) in Sweden 1749–1960 and Denmark 1650–1960.

Swedish and Danish historical data

Education

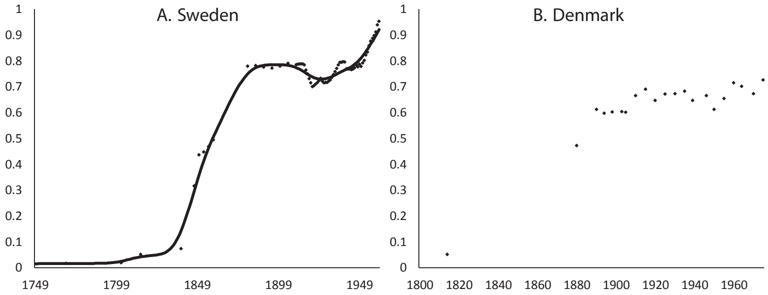


Figure: Enrollment rates to primary education in Sweden 1749–1960 and Denmark 1810–1970.

Swedish and Danish historical data

Output

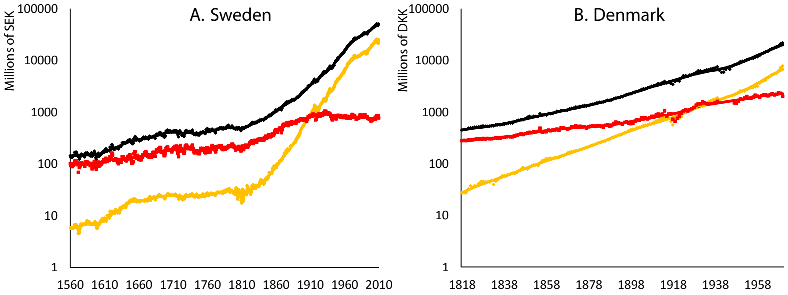


Figure: Industrial (orange), agricultural (red) and total (black) GDP in Sweden 1560–2010 and Denmark 1818–1960.

Summary of evidences

- Despite a mortality and fertility penalty for cities, urbanization took place
- No way to use existing data to estimate the role played by the rural exodus
- Need for structural estimation

OLG Model - 2 areas

Rural area (R):

- produces an agricultural good with labor and land:

$$Y_t^R = A_{R,t} M_{R,t}^{1-\theta} X^{\theta}$$

- land is a public good and labor $(M_{R,t} \equiv \bar{a}_t L_{R,t})$ is compensated by

$$w_t^R = \frac{Y_t^R}{M_{R,t}}$$

Urban area (U):

- Firms produce a manufactured good with efficient labor:

$$Y_t^U = A_{U,t} H_t^{\gamma}$$

- Efficient labor $(H_t \equiv \bar{h}_t L_{U,t})$ is compensated by

$$w_t^U = \frac{p_t Y_t^U}{H_t}$$

OLG Model - Technological Progress

The take-off in the general technological progress depends on population density (Galor and Weil, 2000):

$$\frac{A_{t+1} - A_t}{A_t} = \begin{cases} 0 & \text{if} \quad N_t < \overline{N} \\ \Gamma > 0 & \text{if} \quad N_t \geq \overline{N} \end{cases}$$

$$\begin{aligned} A_{R,t} &= B_{R,t} A_t \\ A_{U,t} &= B_{U,t} A_t H_t^{1-\gamma} \end{aligned}$$

Human capital accumulates according to (De la Croix and Doepke, 2003):

$$h_{t+1} = (\upsilon + e_t)^{\phi} \, h_t^{\psi}$$

OLG Model - Individuals

Each individual lives for two periods:

- Childhood: no consumption, innate agricultural abilities (a), may receive education (e_t)
- Adulthood: decide where to live before consuming and becoming parents

Well-being of adults in both areas depends on:

- Nourishment (Consumption of an agricultural good c_t)
- Consumption of industrial goods (d_t)
- The surviving number of offspring ($q_t^{\mathbb{A}} n_t$)
- Children's human capital (h_{t+1})

Utility of an agent living in area $\mathbb{A}$ is denoted $W_t|\mathbb{A}$:

$$W_t|\mathbb{A} = \alpha \ln (c_t - \bar{c}) + (1-\alpha) \ln(d_t + \varepsilon) + \rho \left[\ln \left(q_t^{\mathbb{A}} n_t \right) + \ln \left(h_{t+1} \right) \right]$$

OLG Model - Budget Constraint

Maximizing utility, rational agents are constrained by individual income spend for:

- Agricultural (c_t) and industrial consumption ($p_t d_t$)
- Offspring
  - Time cost to raise children ($\left(\xi + \zeta q_t^{\mathbb{A}}\right) \omega_t^{\mathbb{A}} n_t$)
  - Education ($\beta p_t q_t^{\mathbb{A}} n_t e_t$)
- Potential migration costs (κ)

Income and expenses are summarized in the budget constraint:

$$c_t + p_t d_t + \left(\xi + \zeta^{\mathbb{A}} q_t^{\mathbb{A}}\right) \omega_t^{\mathbb{A}} n_t + \beta q_t^{\mathbb{A}} p_t n_t e_t = \omega_t^{\mathbb{A}} - \kappa$$

OLG Model - Regimes

R.	c_t	n_t	d_t	e_t	Exod.
1	$\omega_t^{\mathbb{A}}$	0	0	0	No
2	$\frac{\alpha\omega_t^{\mathbb{A}}}{\alpha+\rho} + \frac{\rho}{\alpha+\rho}\bar{c}$	$\frac{\rho\left(\omega_t^{\mathbb{A}}-\bar{c}\right)}{(\alpha+\rho)\left(\xi+\zeta^{\mathbb{A}}q_t^{\mathbb{A}}\right)\omega_t^{\mathbb{A}}}$	0	0	No
3	$\frac{\alpha\left(\omega_t^{\mathbb{A}}-\kappa\right)}{\alpha+\rho} + \frac{\rho}{\alpha+\rho}\bar{c}$	$\frac{\rho\left(\omega_t^{\mathbb{A}}-\kappa-\bar{c}\right)}{(\alpha+\rho)\left(\xi+\zeta^{\mathbb{A}}q_t^{\mathbb{A}}\right)\omega_t^{\mathbb{A}}}$	0	0	Yes
4	$\frac{\alpha\tilde{\omega}_t^{\mathbb{A}}}{1+\rho} + \tilde{c}$	$\frac{\rho\left(\tilde{\omega}_t^{\mathbb{A}}-\bar{c}\right)}{(1+\rho)\left(\xi+\zeta^{\mathbb{A}}q_t^{\mathbb{A}}\right)\omega_t^{\mathbb{A}}}$	$\frac{1-\alpha}{1+\rho}\frac{\left(\tilde{\omega}_t^{\mathbb{A}}-\bar{c}\right)}{p_t} - \varepsilon$	0	Yes
5	$\frac{\alpha\left(\omega_t^{\mathbb{A}}-\kappa\right)}{\alpha+\rho} + \frac{\rho}{\alpha+\rho}\bar{c}$	$\frac{\rho(1-\phi)\left(\omega_t^{\mathbb{A}}-\kappa-\bar{c}\right)}{(\alpha+\rho)\pi_t}$	0	$\frac{\phi\pi_t-(1-\phi)\beta p_t q_t^{\mathbb{A}}\upsilon}{(1-\phi)\beta q^{\mathbb{A}}}$	Yes
6	$\frac{\alpha\tilde{\omega}_t^{\mathbb{A}}}{1+\rho} + \tilde{c}$	$\frac{\rho(1-\phi)\left(\tilde{\omega}_t^{\mathbb{A}}-\bar{c}\right)}{(1+\rho)\pi_t}$	$\frac{1-\alpha}{1+\rho}\frac{\left(\tilde{\omega}_t^{\mathbb{A}}-\bar{c}\right)}{p_t} - \varepsilon$	$\frac{\phi\pi_t-(1-\phi)\beta p_t q_t^{\mathbb{A}}\upsilon}{(1-\phi)\beta p_t q_t^{\mathbb{A}}}$	Yes

with $\tilde{\omega_t}^{\mathbb{A}} = \omega_t^{\mathbb{A}} - \kappa + \varepsilon p_t$, $\tilde{c} = \frac{1-\alpha+\rho}{1+\rho}\bar{c}$ and $\pi_t = \left(\xi + \zeta^{\mathbb{A}}q_t^{\mathbb{A}}\right)\omega_t^{\mathbb{A}} - \beta p_t q_t^{\mathbb{A}}\upsilon$

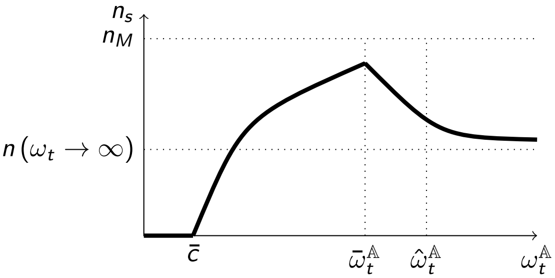
Table: Regimes in which adults can live

Migration decision: people will live in the area providing them the highest expected utility

An OLG-Model

Relation between fertility and income when $\upsilon > \bar{\upsilon}_t$ and $p_t \in]p^*(\kappa), \tilde{p}(\kappa)]$

$$n_t = \begin{cases} 0 & \text{if } \omega_t^{\mathbb{A}} \leq \bar{c} \\ \frac{\rho\left(\omega_t^{\mathbb{A}} - \bar{c}\right)}{(\alpha+\rho)\left(\xi+\zeta q_t^{\mathbb{A}}\right)\omega_t^{\mathbb{A}}} & \text{if } \bar{c} < \omega_t^{\mathbb{A}} \leq \bar{\omega}_t \\ \frac{\rho(1-\phi)\left(\omega_t^{\mathbb{A}} - \kappa - \bar{c}\right)}{(\alpha+\rho)\left[\phi\left(\xi+\zeta q_t^{\mathbb{A}}\right)\omega_t^{\mathbb{A}} - \beta p_t q^{\mathbb{A}} \upsilon\right]} & \text{if } \bar{\omega}_t < \omega_t^{\mathbb{A}} \leq \hat{\omega}_t \\ \frac{\rho(1-\phi)\left(\tilde{\omega}_t^{\mathbb{A}} - \bar{c}\right)}{(1+\rho)\left[\phi\left(\xi+\zeta q_t^{\mathbb{A}}\right)\omega_t^{\mathbb{A}} - \beta p_t q_t^{\mathbb{A}} \upsilon\right]} & \text{if } \omega_t^{\mathbb{A}} > \hat{\omega}_t \end{cases}$$



General Equilibrium

Thanks to the Walras' law, we know that markets are clearing if the three following conditions are met:

$$w_t^U = A_t^U p_t$$

$$\sum_{\mathcal{I}_R} a^i \left[1 - \left(\xi + \zeta^{\mathbb{A}} q_t^{\mathbb{A}}\right) n_t\right] = X \left(\frac{A_t^R}{w_t^R}\right)^{\frac{1}{\theta}}$$

$$\sum_{\mathcal{I}_U} d_t^i + \sum_{\mathcal{I}_R} d_t^i = A_t^U \sum_{\mathcal{I}_U} h_t^i l_t^i$$

Resource constraint of the economy:

$$Y_t = p_t Y_t^U + Y_t^R = \sum_{\mathcal{I}_U} \left(c_t^i + p_t d_t^i + \beta p_t q_t^U e_t^i n_t^i\right) + \sum_{\overline{\mathcal{I}}_U \bigcup \overline{\mathcal{I}}_R} \bar{\kappa} + \sum_{\mathcal{I}_R} (c_t^i + p_t d_t^i + \beta p_t q_t^R e_t^i n_t^i) e$$

Calibration - Identification strategy

- Model aims at reproducing trends in urban and rural fertility as well as urbanization between 1760 and 1960 but not gdp and education.

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- GDP is normalized by agricultural production in $t = 0$

Calibration

A priori fixed parameters

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- Time to give birth approximated by Coale's index: $\xi = \frac{1}{\text{Fert}_{\text{hut}}} - \zeta q_{\text{MIN}}$

Calibration

Distance minimization and market equilibria

- We minimize the distance between observed and simulated moments:

$$f(p) = [d - s(p)]\, W\, [d - s(p)]'$$

by PIKAIA (Charbonneau, 2002) and UOBYQA (Powell, 2002)

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Implemented by a hybrid-OpenMP-MPI-parallel program in Fortran 90.

Calibration and Simulation exercise

Parameter	Sym.	Denmark	Sweden
Elasticity between c and d	α	0.512	0.655
Cost of education	β	3.629	0.117
Stone-Geary element in d	ε	3.938	2.460
Time to rear a child in countryside	ζ^R	0.192	0.093
Additional costs of childrearing in U	ζ^U	1.889	1.262
Cost of moving	$\bar{\kappa}$	2.336	1.937
Average initial human capital	λ	1.015	1.866
Constant in HC-accumulation	π	2.788	1.383
Preference for children	ρ	0.925	0.291
Initial TFP in R	A_0^R	126.52	264.059
Initial TFP in U	A_0^U	5.635	0.881
Minimum agric. consumption	$\bar{c}$	1.734	0.602
Exogenous growth rate	g	0.497	0.425
Critical population size	$\bar{N}$	0.732	2.352
Elasticity of educational invest.	ϕ	0.518	0.362
Elasticity of interg. transmission of HC	ψ	0.326	0.648
Number of moments to be matched		18	33
Number of estimated parameters		15	15

Calibration - Fit for Sweden

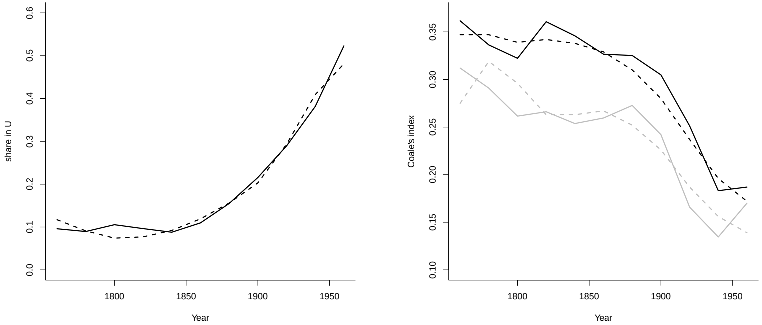
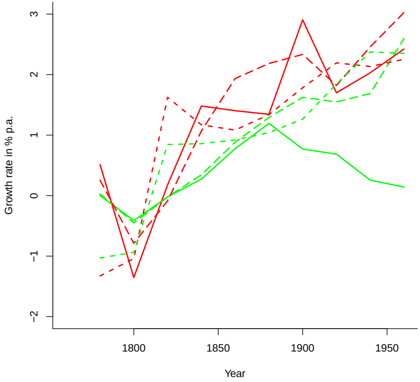
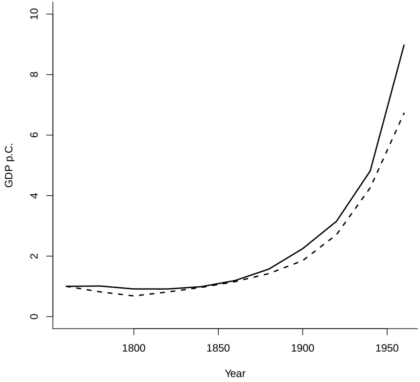


Figure: Urbanization and fertility dynamics in Denmark

Overidentification checks for Sweden



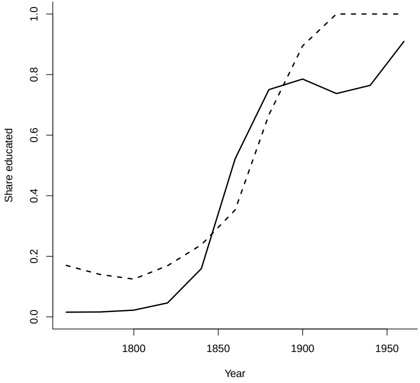
(a) Average annual growth rate of GDP per capita in agriculture (green) and industry (red)



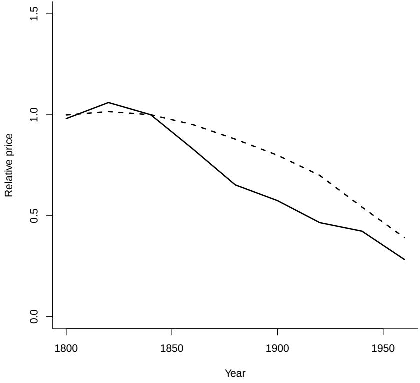
(b) Total GDP per capita

Figure: Observed (solid), adjusted observed (long dashed) and simulated (dashed) GDP per capita and its growth rates

Overidentification checks for Sweden



(a) Enrollment rates in primary education



(b) Relative price

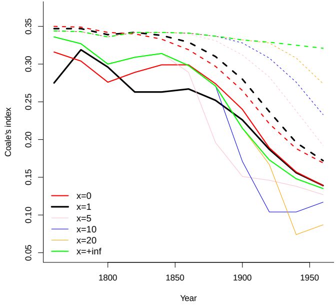
Figure: Observed (solid) and simulated (dashed) enrollment rates in primarey education and relative prices

Historical experiments - Rural Exodus

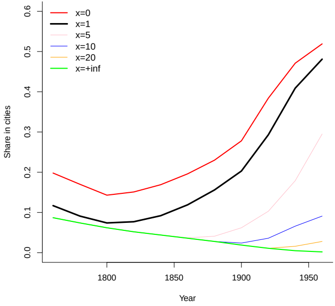
Main idea:

- We simulate our dynamic general equilibrium model for alternative values of $\bar{\kappa}$, such that $\bar{\kappa}' = x\bar{\kappa}$ with $x = \{0, \frac{1}{20}, \frac{1}{10}, \frac{1}{5}, 1, 5, 10, 20, +\infty\}$.
- Focus on higher costs: multiplying by 20 means maintaining the real cost of migration $\frac{\kappa}{y}$ constant between 1760 and 1960
- Any scenario between 0 and 20 corresponds to a decrease in relative migration costs

Counterfactual experiments - Rural Exodus

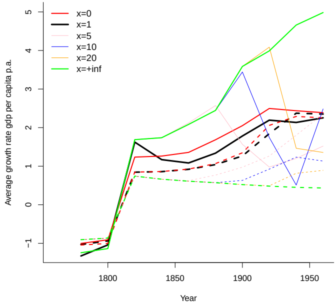


(a) Urban (solid) and rural (dashed) fertility

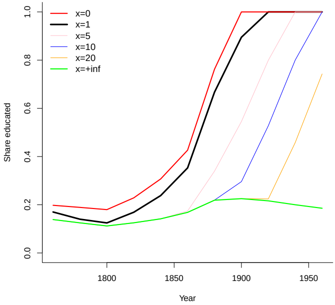


(b) Urbanization

Counterfactual experiments - Rural Exodus

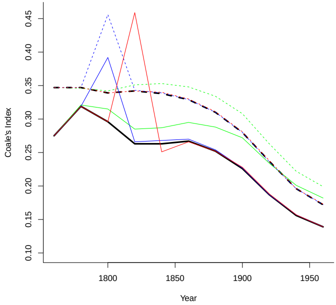


(c) Industrial (solid) and agricultural (dashed) growth rates of gdp per capita

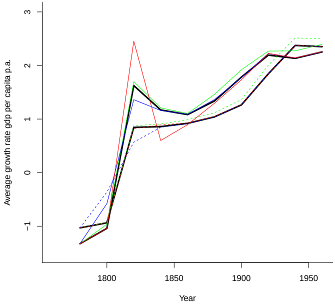


(d) Education

Alternative experiments - Stagnation of mortality

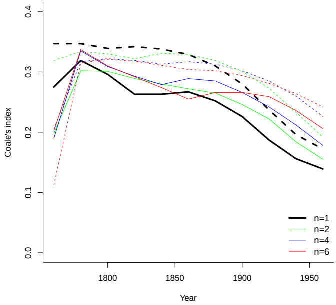


(e) Industrial (solid) and agricultural (dashed) growth rates of gdp per capita

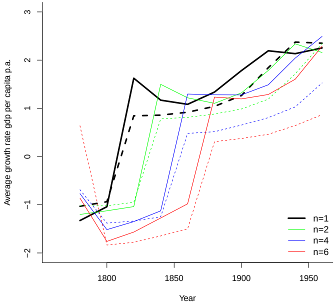


(f) Fertility

Alternativel experiments - Enclosures



(g) Industrial (solid) and agricultural (dashed) growth rates of gdp per capita



(h) Fertility

Conclusion

Findings:

- The rural exodus was much more important for economic dynamics and the fertility transition than improvements in infant mortality and enclosures
- Excluding the rural exodus:
  - The fertility transition in the countryside disappears but is stronger in cities
  - A small elite in cities becomes richer while the mass in the countryside pauperizes

Appendix

Coale's index

... relates the number of children of population $\mathcal{A}$ to the maximum fertility measured by those of the hutterites:

$$I_t^{\mathcal{A}} = \frac{B_t^{\mathcal{A}}}{\sum_{o=1}^{T} \varepsilon_{o,t}^{\mathcal{A}} n_o^H}$$

- Advantage: controls for effect of age structures
- Approximation of Coale's index in the model:

$$\hat{I}_t^{\mathbb{A}} = \frac{\sum_{\mathcal{I}^{\mathbb{A}}} n_{i,t}^{\mathbb{A}}}{\frac{N_t^{\mathbb{A}}}{2} 5 \sum_o n_o^H}$$

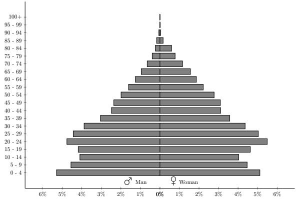
o	15-19	20-24	25-29	30-34	35-39	40-44	45-49
n_o^H	0.3	0.55	0.502	0.447	0.406	0.222	0.061

Table: Age specific fertility of Hutterites (Coale (1969))

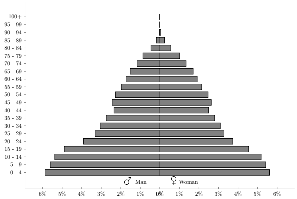
Back to historical data

Age Pyramids

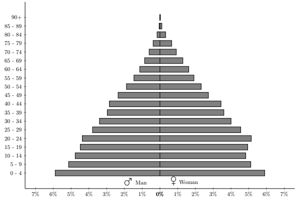
Urban Sweden



Rural Sweden



Urban Denmark



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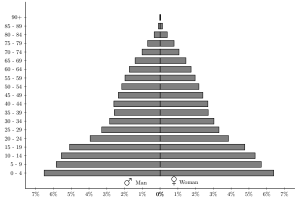

▸ Back to historical data

Population by place of birth and residence in %

Back

Living Place	Place of birth: Copenhagen	Town: Islands	Town: Jutland	Rural parish: Islands	Rural parish: Jutland	Abroad
1850						
Copenhagen	63	8	4	15	3	7
Town (islands)	6	56	5	26	3	4
Town (Jutland)	3	2	61	1	28	5
Rural parish (islands)	2	2	1	93	1	1
Rural parish (Jutland)	0	0	2	1	95	2
1880						
Copenhagen	54	10	5	20	3	8
Town (islands)	5	53	2	35	1	4
Town (Jutland)	3	3	51	3	35	5
Rural parish (islands)	3	3	1	90	1	2
Rural parish (Jutland)	0	0	3	1	94	2
1901						
Copenhagen	53	15		24		8
Town	3	51		41		5
Rural parish	2	4		91		3
1911						
Copenhagen	55	15		22		8
Town	4	52		40		4
Rural parish	3	5		89		3
1930						
Copenhagen	56	15		23		6
Town	4	50		43		3
Rural parish	3	7		88		2
1940						
Copenhagen	55	16		23		6
Town	4	50		43		3
Rural parish	4	8		86		2

Source: Johansen (2002).