Online Appendix

CAN INTERNAL MIGRATION FOSTER THE CONVERGENCE IN REGIONAL FERTILITY RATES?

EVIDENCE FROM NINETEENTH CENTURY FRANCE

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Appendix A.

Appendix Table A1: Descriptive Statistics

	Obs.	Mean	Std.Dev	Min	Max
Coale Fertility Index					
Inhabitants' Residence Norm	486	0.274	0.059	0.158	0.566
Inhabitants' Residence Norm (1811-1861)	486	0.360	0.099	0.205	0.871
Fertility Norms and Share of Emigrants - Main Sample					
Emigrants' Residence Norm	486	0.257	0.038	0.168	0.395
Immigrants' Birthplace Norm	486	0.274	0.035	0.207	0.422
Share of Emigrants	486	0.169	0.074	0.031	0.467
Share of Immigrants	486	0.123	0.081	0.006	0.554
Fertility Norms and Share of Emigrants - Female Sample					
Emigrants' Residence Norm	486	0.255	0.039	0.161	0.390
Immigrants' Birthplace Norm	486	0.275	0.040	0.198	0.496
Share of Emigrants	486	0.164	0.076	0.022	0.471
Share of Immigrants	486	0.119	0.087	0.002	0.583
Fertility Norms and Share of Emigrants - Male Sample					
Emigrants' Residence Norm	486	0.259	0.042	0.173	0.484
Immigrants' Birthplace Norm	486	0.273	0.040	0.190	0.459
Share of Emigrants	486	0.182	0.079	0.039	0.519
Share of Immigrants	486	0.136	0.089	0.009	0.616
Fertility Norms and Share of Emigrants - Excluding Paris					
Emigrants' Residence Norm	480	0.266	0.037	0.168	0.437
Immigrants' Birthplace Norm	480	0.276	0.034	0.207	0.422
Share of Emigrants	480	0.127	0.064	0.011	0.467
Share of Immigrants	480	0.111	0.060	0.006	0.372
Fertility Norms and Share of Emigrants - Extended Sample 1821-1911					
Emigrants' Residence Norm	800	0.306	0.084	0.168	0.774
Immigrants' Birthplace Norm	800	0.303	0.053	0.207	0.510
Share of Emigrants	800	0.146	0.096	0.001	1.258
Share of Immigrants	800	0.114	0.093	0.000	1.069
Crude Birth Rate					
Inhabitants' Residence Norm	480	0.024	0.005	0.008	0.038
Fertility Norms and Share of Emigrants - Main Sample					
Emigrants' Residence Norm	480	0.025	0.004	0.015	0.034
Immigrants' Birthplace Norm	480	0.024	0.004	0.016	0.047
Share of Emigrants	480	0.168	0.074	0.031	0.467
Share of Immigrants	480	0.124	0.082	0.006	0.554

Fertility Norms and Share of Emigrants - Female Sample					
Emigrants' Residence Norm	480	0.024	0.004	0.014	0.033
Immigrants' Birthplace Norm	480	0.024	0.004	0.015	0.047
Share of Emigrants	480	0.164	0.076	0.022	0.471
Share of Immigrants	480	0.119	0.087	0.002	0.583
Fertility Norms and Share of Emigrants - Male Sample					
Emigrants' Residence Norm	480	0.025	0.004	0.014	0.038
Immigrants' Birthplace Norm	480	0.024	0.004	0.015	0.053
Share of Emigrants	480	0.182	0.079	0.039	0.518
Share of Immigrants	480	0.136	0.089	0.009	0.616
Fertility Norms and Share of Emigrants - Excluding Paris					
Emigrants' Residence Norm	474	0.024	0.003	0.014	0.035
Immigrants' Birthplace Norm	474	0.024	0.004	0.016	0.047
Share of Emigrants	474	0.127	0.064	0.011	0.467
Share of Immigrants	474	0.112	0.060	0.006	0.372
Instrumental Variable					
Travel Costs					
Education, health and the workforce					
Life Expectancy at Age 15	486	48.72	7.55	34.76	65.91
Infant Mortality (under age 1, in %)	486	0.217	0.108	0.019	0.626
Urban (% residents living in jurisdictions of more than 2,000 inhabitants)	486	0.280	0.162	0.082	1.000
Industries (% of the workforce in the industrial sector)	486	0.211	0.134	0.001	0.677
Professionals (% of professionals, e.g. lawyers, doctors..., in workforce)	486	0.027	0.016	0.001	0.160
Female Education (% 5-19 year old females in primary and secondary schools)	486	0.499	0.136	0.075	0.792
Male Education (% 5-19 year old males in primary and secondary schools)	486	0.528	0.129	0.149	1.071
Share of girls in Catholic primary schools (in %, out of the total number of girls in Catholic and secular primary schools)	486	0.437	0.182	0.026	0.939
Share of boys in Catholic primary schools (in %, out of the total number of boys in Catholic and secular primary schools)	486	0.166	0.122	0.010	0.727
Revue des Deux Mondes Outlets (t)	486	0.597	0.816	0	4
Variables for robustness checks					
Total Number of Periodicals	486	51.31	253.45	2	4021
New Catholic Church	486	0.506	0.990	0	11
New Orthodox Church	486	0.004	0.064	0	1
New Protestant Temple	486	0.029	0.179	0	2
Share of Children Born out of Wedlock out of the Total Number of Births	486	0.063	0.055	0	1
Share of not legitimised Children out of those who were Born out of Wedlock	486	0.664	0.185	0.095	1
Share of Married Men Age 20-24	486	0.119	0.056	0.021	0.431
Share of Married Women Age 20-24	486	0.462	0.142	0.172	0.899
Share of Married Men Age 25-29	486	0.488	0.113	0.072	0.871
Share of Married Women Age 25-29	486	0.699	0.091	0.277	0.868
Share of Married Men Age 30-34	486	0.678	0.132	0.248	0.860
Share of Married Women Age 30-34	486	0.772	0.070	0.472	0.968
Quantity of Mineral Fuels Consumed by Mineral Industries	486	963416.2	2660328	2400	37205100
Wheat Prices	485	21.49	3.54	14.1	28.89

Table A2. The Relationship between Each Underlying Regressor and its Instrumented Counterpart: OLS Regressions

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	OLS	OLS
	Dependent variable is the instrumented value of					
	Emigrants' Residence Norm (t)	Immigrants' Birthplace Norm (t)	Emigrants' Residence Norm(t)* Share of Emigrants(t)	Immigrants' Birthplace Norm (t)* Share of Immigrants(t)	Share of Emigrants(t)	Share of Immigrants (t)
Underlying Regressor						
Emigrants' Residence Norm (t)	0.272					
	[0.023]***					
Immigrants' Birthplace Norm (t)		0.227				
		[0.021]***				
Emigrants' Residence Norm (t) * Share of Emigrants(t)			0.534			
			[0.060]***			
Immigrants' Birthplace Norm (t)* Share of Immigrants (t)				0.443		
				[0.042]***		
Share of Emigrants(t)					0.445	
					[0.065]***	
Share of Immigrants (t)						0.386
						[0.049]***
Adjusted R2	0.94	0.94	0.86	0.95	0.84	0.95
F-stat	1277.29	1057.25	285.1	427.12	184.11	259.38
F-stat p-value	0.000	0.000	0.000	0.000	0.000	0.000
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Département-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	486	486	486	486	486	486

Note: These regressions relate the underlying value of the main regressors to their instrumented value in OLS regressions with year- and fixed- effects. All the variables are in logarithms. Standard errors are reported in brackets. *** indicates significance at the 1% level, ** at the 5%-level, * at the 10%-level.

Table A3. Migration and the Fertility Decline, 1861-1911, Accounting for the Deviation in Wheat Prices (Coale Fertility Index)

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	IV	IV	IV
	Dependent variable is Fertility(t)					
Emigrants' Residence Norm (t)	0.386***	0.367***	0.373***	0.968***	0.929***	0.942***
	[0.101]	[0.101]	[0.101]	[0.240]	[0.239]	[0.241]
Immigrants' Birthplace Norm (t)	-0.101	-0.0964	-0.0995	0.198	0.241	0.238
	[0.0939]	[0.0909]	[0.0917]	[0.268]	[0.268]	[0.273]
Emigrants' Residence Norm (t) * Share of Emigrants(t)	-1.277**	-1.167**	-1.199**	-3.158***	-3.098***	-3.153***
	[0.607]	[0.577]	[0.582]	[0.821]	[0.824]	[0.816]
Immigrants' Birthplace Norm (t)* Share of Immigrants (t)	2.859***	2.812***	2.830***	1.150	1.156	1.167
	[0.726]	[0.724]	[0.728]	[0.901]	[0.927]	[0.921]
Share of Emigrants (t)	-1.909**	-1.768**	-1.811**	-4.262***	-4.209***	-4.286***
	[0.919]	[0.859]	[0.870]	[1.247]	[1.248]	[1.238]
Share of Immigrants (t)	4.780***	4.756***	4.792***	2.168*	2.226*	2.240*
	[0.986]	[0.990]	[0.991]	[1.237]	[1.285]	[1.276]
Life Expectancy Age 15 (t)	-0.0104	-0.00857	-0.00798	-0.0111	-0.00950	-0.00871
	[0.0101]	[0.00944]	[0.00940]	[0.0104]	[0.0103]	[0.0103]
Infant Mortality (t)	0.655*	0.724**	0.745**	0.563	0.618*	0.646*
	[0.337]	[0.307]	[0.305]	[0.339]	[0.333]	[0.332]
log(Urban) (t)	-0.0111	-0.00740	-0.00577	0.213	0.221	0.225
	[0.297]	[0.295]	[0.296]	[0.288]	[0.285]	[0.285]
log(Industries) (t)	-0.00952	-0.0110	-0.0110	0.00151	0.000417	0.000386
	[0.00766]	[0.00770]	[0.00767]	[0.00766]	[0.00766]	[0.00768]
log(Professionals) (t)	-0.0151	-0.0153	-0.0152	-0.00731	-0.00750	-0.00731
	[0.0132]	[0.0133]	[0.0132]	[0.0124]	[0.0123]	[0.0123]
log(Female Education (t))	-0.0328	-0.0262	-0.0277	-0.0162	-0.00856	-0.0110
	[0.0389]	[0.0383]	[0.0383]	[0.0377]	[0.0370]	[0.0374]
log(Male Education (t))	0.0161	0.00774	0.00767	0.0110	0.00347	0.00396
	[0.0472]	[0.0471]	[0.0470]	[0.0489]	[0.0491]	[0.0490]
log(Share of Girls in Primary Catholic Schools) (t)	0.00813	0.00733	0.00773	0.0133	0.0121	0.0129
	[0.0181]	[0.0181]	[0.0181]	[0.0200]	[0.0203]	[0.0203]
log(Share of Boys in Primary Catholic Schools) (t)	0.00277	0.00300	0.00247	0.00828	0.00895	0.00835
	[0.0156]	[0.0156]	[0.0156]	[0.0149]	[0.0151]	[0.0151]
Revue des Deux Mondes Outlets (t)	0.0584	0.0571	0.0573	0.0121	0.0112	0.0112
	[0.0354]	[0.0359]	[0.0360]	[0.0395]	[0.0399]	[0.0399]
Revue des Deux Mondes Outlets (t)* Fertility of Seine (t)	0.0411*	0.0395	0.0397	0.0152	0.0142	0.0142
	[0.0239]	[0.0244]	[0.0245]	[0.0274]	[0.0278]	[0.0278]
Deviation Wheat Prices (t)	-0.00739*			-0.00643*		
	[0.00416]			[0.00364]		
Squared Deviation Wheat Prices (t)		-0.00210			-0.00238	
		[0.00230]			[0.00216]	
Absolute Deviation Wheat Prices (t)			-0.00301			-0.00266
			[0.00647]			[0.00591]
Constant	-0.720	-0.844	-0.875	0.454	0.370	0.336
	[0.596]	[0.548]	[0.544]	[0.627]	[0.619]	[0.620]
Within R2	0.763	0.761	0.761	0.777	0.776	0.776
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Département-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of clusters	81	81	81	81	81	81
Observations	485	485	485	485	485	485

Note: All the variables are in logarithms, except for the deviation in Wheat Prices defined as Deviation Wheat Prices (t) $= (Wheat\ Prices_{it} - mwp_t)/swp_t$, where $Wheat\ Prices_{it}$ is the price of wheat in département i in year t, mwp_t is the average wheat price in year t and swp_t is the standard deviation of wheat prices in year t. Robust standard errors clustered at the département-level are reported in brackets. *** indicates significance at the 1% level, ** at the 5%-level, * at the 10%-level.

Appendix B. Unconditional Convergence in Départemental Fertility Rates

Following our discussion in Section 2, where we discuss the convergence in the fertility levels across the French départements, we run a series of unconditional convergence regressions of the standard form in the growth regression literature (e.g., Barro and Sala-i-Martin, 1992):

$$\log[(f_{i,t+10})/(f_{i,t})] = a.\log(f_{i,t}) + \alpha_i + \alpha_t + \varepsilon_{i,t} \quad \text{(B.1)}$$

where $f_{i,t}$ is the fertility rate in département i and year t α_i and α_t are département- and year-fixed effects ε is an error term such that ε⟶ $\mathcal{N}(0,\sigma^2)$. In line with the literature, we view a negative and significant coefficient associated with $f_{i,t}$ as evidence of unconditional convergence.

We report in Appendix Table B.1 estimates of Equation (B.1) using the Coale fertility index over our main sample period (1861-1911) as well as over other samples (1821-1911, 1821-1851), as well as the Total Fertility Rate over the 1861-1911 period. In all these regressions, the coefficient associated with the fertility rate is negative and significant, suggesting that there was an unconditional convergence of local fertility rates in France during the nineteenth century.

Appendix Table B.1: Unconditional Convergence Test of Fertility: France before WWI

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
	Dependent variable is Fertility(t+10)/Fertility(t)			
	Coale Fertility Index 1861-1911	Coale Fertility Index 1821-1911	Coale Fertility Index 1821-1851	Total Fertility Rate 1861-1911
Fertility(t)	-0.566***	-0.235***	-0.972***	-0.200***
	[0.0676]	[0.0639]	[0.118]	[0.0389]
Constant	0.338***	0.695***	0.0430	0.267*
	[0.0888]	[0.0889]	[0.129]	[0.140]
Within R2	0.5	0.3	0.4	0.7
Year-fixed effects	Yes	Yes	Yes	Yes
Département-fixed effects	Yes	Yes	Yes	Yes
Clusters	81	80	80	80
Observations	405	720	240	400

Note: All variables are in logarithms. Robust standard errors clustered at the region level are reported. *** indicates significance at the 1% level, ** at the 5%-level, * at the 10%-level.

Estimates of Equation (B.1) are reported in Appendix Table B.2 for England and Wales, Italy and Germany. In these regressions, the coefficient associated with the fertility rate is not negative, thereby suggesting that the unconditional convergence of regional fertility rates is a specific French feature.

Appendix Table B.2: Unconditional Convergence Test of Fertility: England and Wales, Germany, and Italy before WWI

Dependent variable is $\left(f_{i,t+10}/f_{i,t}\right)$			
	England and Wales (1851-1911)	Germany (1871-1910)	Italy (1871-1910)
$f_{i.t}$	0.07**	0.07**	0.20
	[0.03]	[0.03]	[0.11]
Year= 1861	-0.03***		
	[0.01]		
Year= 1871	-0.07***		
	[0.01]		
Year= 1881	-0.18***	-0.08***	-0.00
	[0.01]	[0.01]	[0.02]
Year= 1891	-0.17***	-0.05***	0.00
	[0.01]	[0.01]	[0.02]
Year= 1901	-0.20***	-0.18***	-0.02
	[0.01]	[0.01]	[0.02]
Constant	0.11***	-0.09***	-0.17
	[0.03]	[0.03]	[0.11]
Observations	276	284	64
R^2	0.81	0.59	0.09

Note: All variables are in logarithms. Robust standard errors clustered at the region level are reported. Sources: The regressions rely on the Fertility Coale Indices of England & Wales, Germany and Italy. Princeton Project on the Decline of Fertility in Europe for the other countries.

The existence of an unconditional convergence in regional fertility rates in France, and its absence in England & Wales, Germany and Italy, is illustrated in Figure B.1 where we graph the fertility of rates within each country in comparison to the country's capital. It can further be observed in Figures B.2-B4 that there is no convergence in fertility rates in England & Wales, Germany and Italy during the 1861-1911 period.

Figure B1: Fertility Rates in France, England, Germany and Italy

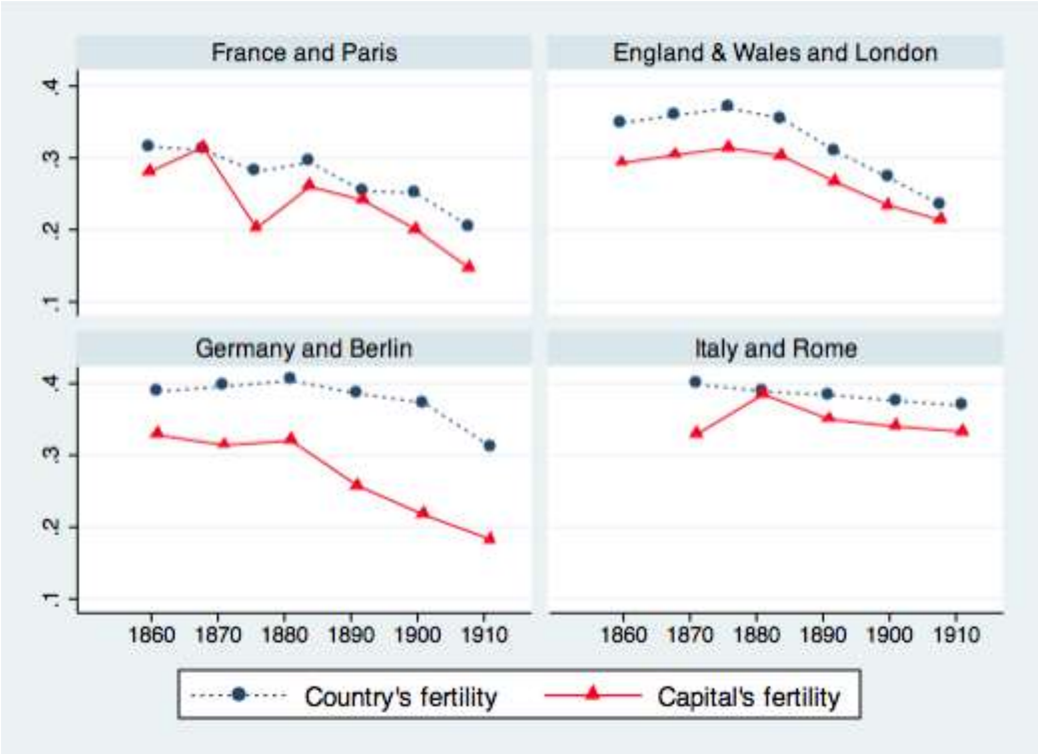


Figure B2: Fertility Distribution in England and Wales, 1861-1911

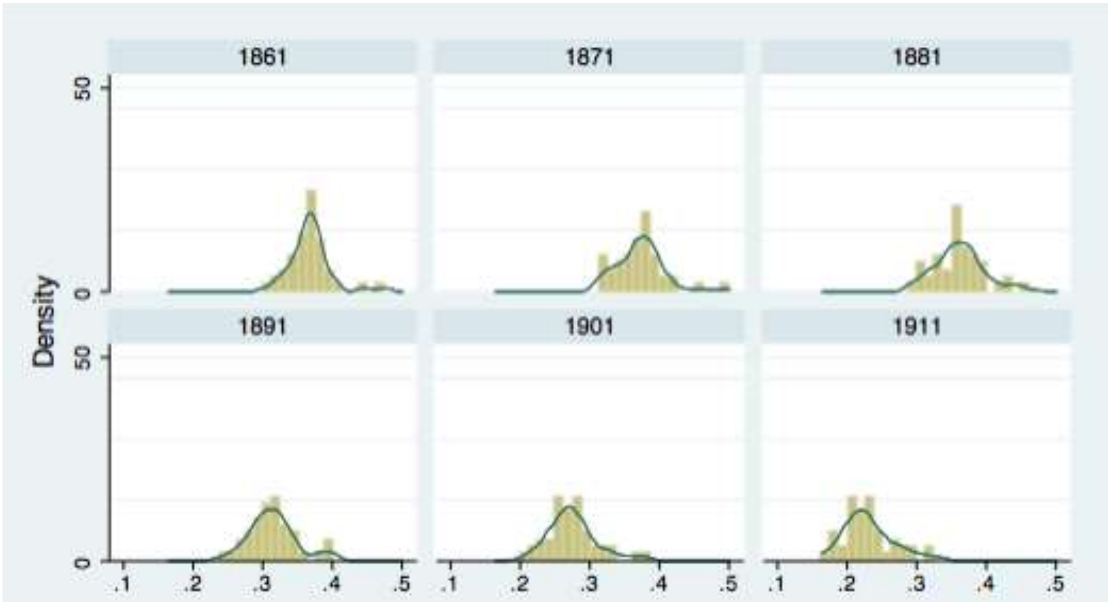


Figure B3: Fertility Distribution in Germany, 1871-1910

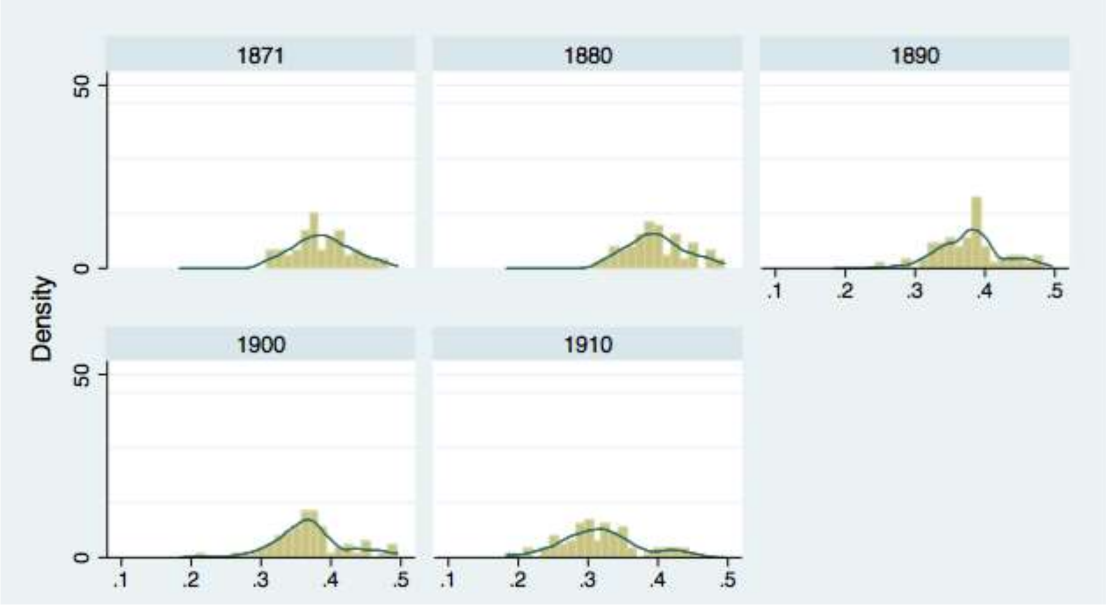
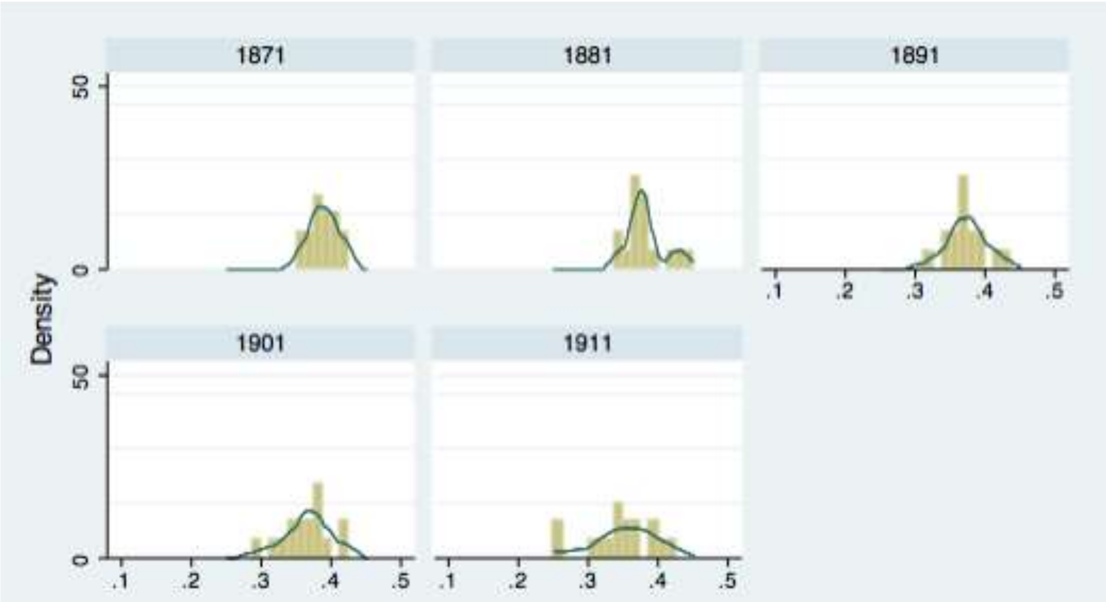


Figure B4: Fertility Distribution in Italy, 1871-1910



Note: These Figures graph the Fertility Coale Indices of France, England & Wales, Germany and Italy with their respective capitals. In all the countries, the capital's fertility is lower than that of the whole country. The Figure shows that there is a secular decline in fertility in France during the nineteenth century. However, the fertility decline in England & Wales and Germany only begins after 1880 while it does not seem to occur in Italy before WWI. Moreover, there was almost no convergence in the fertility rates across the regions of England & Wales, Germany and Italy before WWI

Sources: Bonneuil (1997) and authors' computation for 1911 for France. Princeton Project on the Decline of Fertility in Europe for the other countries.

Finally, it is worth noting that in this study, our main specification follows models of fertility determination and is therefore slightly different from the usual specification of growth regression model in Equation (B.1).

$$\log(f_{i,t}) = a_1 . \log(f_{i,t-10}) + \alpha_t + \varepsilon_{i,t} \quad \text{(B.2)}$$

where all the variables were defined above. Given the difference in specifications between Equations (B.1) and (B.2), there would be evidence of unconditional convergence in Equation (B.2) if the coefficient associated with the lagged fertility rate is below 1.

The estimates of Equation (B.2) reported in Appendix Table B.3 confirm the unconditional convergence of fertility in nineteenth century France.

Appendix Table B.3: Unconditional Convergence Test of Fertility: France before WWI

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
	Dependent variable is Fertility(t)			
	Coale Fertility Index 1861-1911	Coale Fertility Index 1821-1911	Coale Fertility Index 1821-1851	Total Fertility Rate 1861-1911
Fertility(t-10)	0.841***	0.856***	0.886***	0.843***
	[0.0215]	[0.0141]	[0.0166]	[0.0696]
Constant	-0.338***	-0.237***	-0.215***	-0.540**
	[0.0289]	[0.0223]	[0.0185]	[0.255]
Within R2	0.8	0.9	0.9	0.8
Year-fixed effects	Yes	Yes	Yes	Yes
Clusters	81	80	80	80

Note: All variables are in logarithms. Robust standard errors clustered at the region level are reported.
*** indicates significance at the 1% level, ** at the 5%-level, * at the 10%-level.

Appendix C. The TRA Data and the Computation of the Total Number of Emigrants and Immigrants at the Département Level with the Iterative Proportional Fitting Procedure (also Known as the RAS Algorithm)

This Appendix discusses how the bilateral migration TRA data can be transformed to reflect the total number of emigrants and immigrants at the *département* level with a standard marginalization algorithm known as the RAS algorithm.

The first step is to compute the implied bilateral migrant stocks in any given year from the TRA data. For this purpose, we assume that people who died in a different *département* from their birth *département* migrated at age 20.[1] This provides us with $m_{ij,t}^{TRA}$ which is the number of migrants from *département* i living in département j in each year t (with t= 1821, 1831, 1841, 1851,1861, 1872, 1881, 1891, 1901 and 1911) in the TRA dataset.

The second step for the 1861-1911 period is to gather the number of domestic immigrants and emigrants from each *département* from the census. These data are published in the 1891, 1901 and 1911 issues of the French census. In the issues of the census published in 1861, 1872 and 1881, the number of immigrants is given as the number of individuals in each *département* who were born in another *département*. We can then compute the number of emigrants using information on birth rates, mortality rates, the number of inhabitants and the number of emigrants published in the next issue of the census.[2] This provides us with $m_{i.,t}^{Census}$ and $m_{.j,t}^{Census}$which are respectively the total number domestic emigrants from each *département* i and immigrants in each *département* j for each year.

Our third stage is to transform the TRA dataset so as to obtain a matrix which is defined by the margins coming from the census and the odds ratios (the ratio between, for example, the odds of an immigrant in *département* A to be an emigrant from

[1] This assumption is based on computations of thecourse an approximation. Using net positive migration rates by age using data from (Bonneuil 1997), we computed that the mean age at migration was 19.4 years in 1861, 18.6 in 1872, 22.5 in 1881 and, 21.4 in 1891.

[2] For simplicity we ignore emigration to foreign countries – which was anyway small - and the small number of emigrants from Alsace-Lorraine (which was seized by Germany after 1871) by assuming they were a fixed proportion of emigrants in each *département* throughout the country.

département B instead of being from C and the odds of an immigrant in *département* D to be an emigrant from *département* B instead of being from C) coming from the TRA (See (Smith 1976), p. 672-3). For this purpose, we apply a marginal standardization algorithm known as the RAS algorithm (see Smith (1976) and Cox (1998)).[3] This is meant to reconcile the bilateral matrix composed of $m_{ij,t}^{TRA}$with its margins composed of $m_{i.,t}^{Census}$ and $m_{.j,t}^{Census}$, or find the $m_{ij,t}^{RAS}$ such as $\sum_i m_{ij,t}^{RAS} = m_{.j,t}^{Census}$ and $\sum_j m_{ij,t}^{RAS} = m_{i.,t}^{Census}$ and $m_{ij,t}^{RAS}$ is 'close' to $m_{ij,t}^{TRA}$. The algorithm works by multiplying by a scalar alternatively the lines and the columns of the matrix so that $\sum_i m_{ij,t}^{k^{th}\ iteration} = m_{.j,t}^{Census}$ or $\sum_j m_{ij,t}^{k^{th}\ iteration} = m_{i.,t}^{Census}$. This goes on till the sums of both the lines and column are nearly equal to the pre-defined margins.

These transformed TRA data then become our main measure of bilateral migration. A similar procedure is used to compute male and female migration, except that the gender differentiated margins for 1891 have to be extrapolated from the 1881 and the 1901 census.

The procedure is different for 1821-1851 because the successive issues of the census for that period only provide the number of residents in each *département* and not the number of individuals in each *département* who were born in another *département.* This implies that we have to compute the number of living natives of each *département*, which is the difference between "living natives" and "native deaths". We compute the number of living natives of each *département* by backward induction, starting from the year t+10 native population and computing the natural increase from year t to year t+10. Native births are by definition the number of births in the *département* and are directly available from the census. Native deaths must however be computed by assuming that all individuals migrate at age 20. They are the sum of the number of deaths of individuals age 0 20 in the *département* and of the number of deaths of natives over 20 years in all *départements*, assuming the same age structure and mortality rates as in each migrant's destination *département*, which we obtain from the age-specific mortality rates in Bonneuil (1997).

We can then proceed to the third stage of the procedure where we match these data to the TRA dataset (one margin is formed by natives, the other one by residents).

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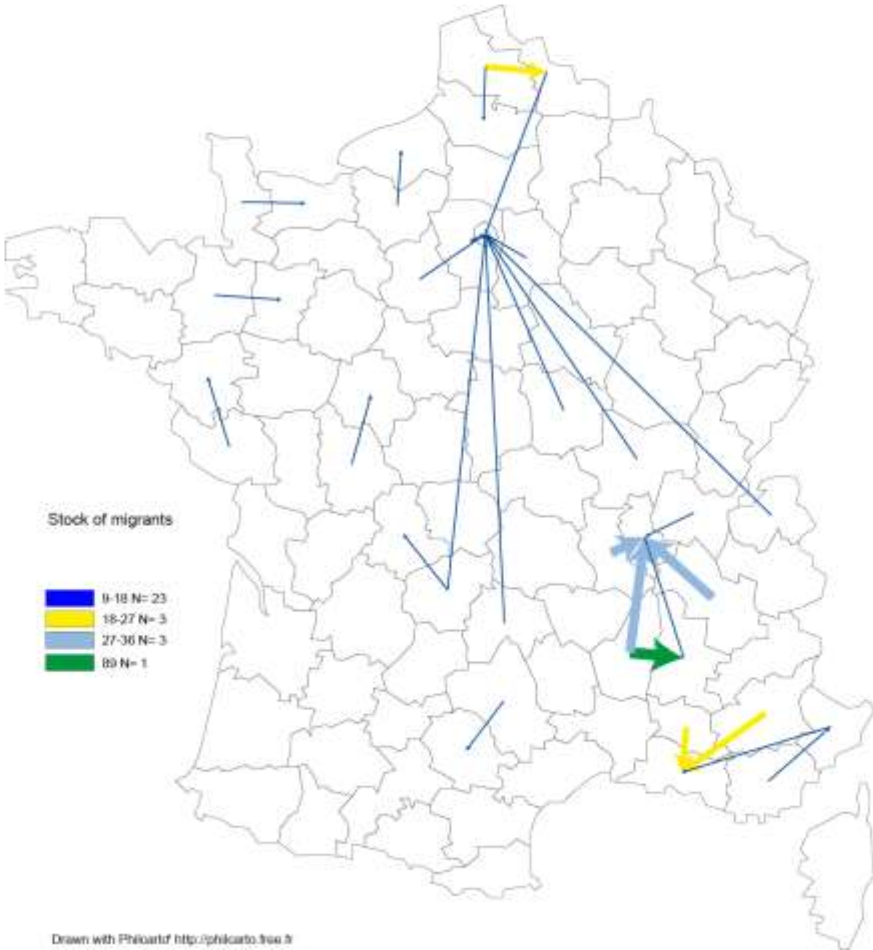
[3] This procedure is also known as biproportional matrices, iterative proportional fitting or raking.

The outcome of this procedure is however more uncertain over the 1821-1851 period than for the post-1851 period because we have to compute the number of "stayers" with the Iterative Proportional Fitting Procedure. In contrast, starting 1861, the number of "stayers" is given by the census.

Figure C1: Bilateral Migrant Stocks > 11, TRA Data, 1891



Note: In the legend, the first two numbers represent the bounds of the bracket for the stock of migrants; N represents the number of links between *départements* in each bracket.

Appendix D: The State of the Development of the Railroad Network Following "L'étoile de Legrand".

1850

1860

1870

1891

1910-1930

Source: Caron (1997).