Introducing Railway Time in the Balkans

Economic effects of railway construction in Southeast Europe and beyond since the early 19^{th} century until present days*

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Overview

1. Introduction
2. Data
3. Country Level Analysis
4. City Level Analysis
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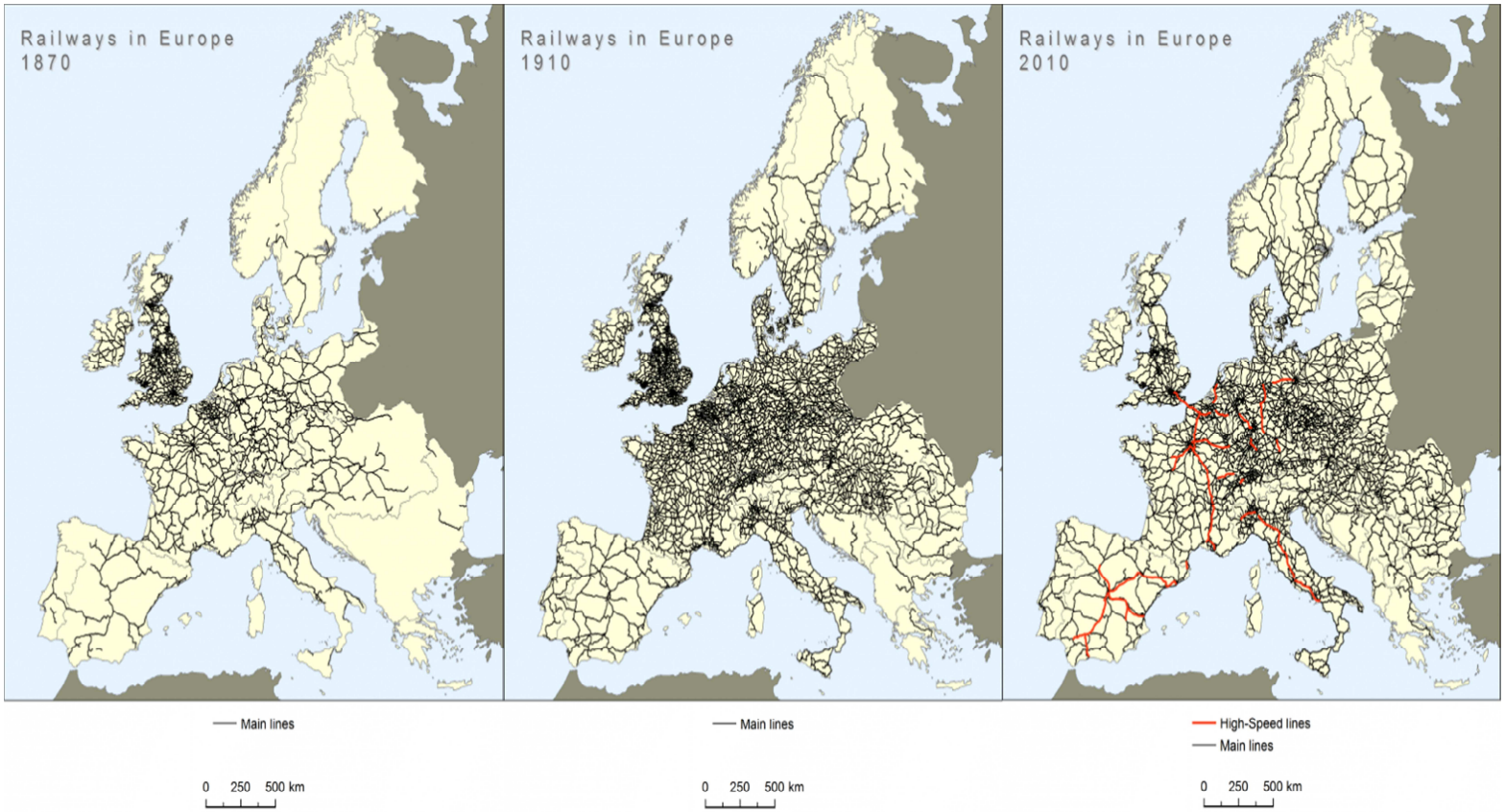
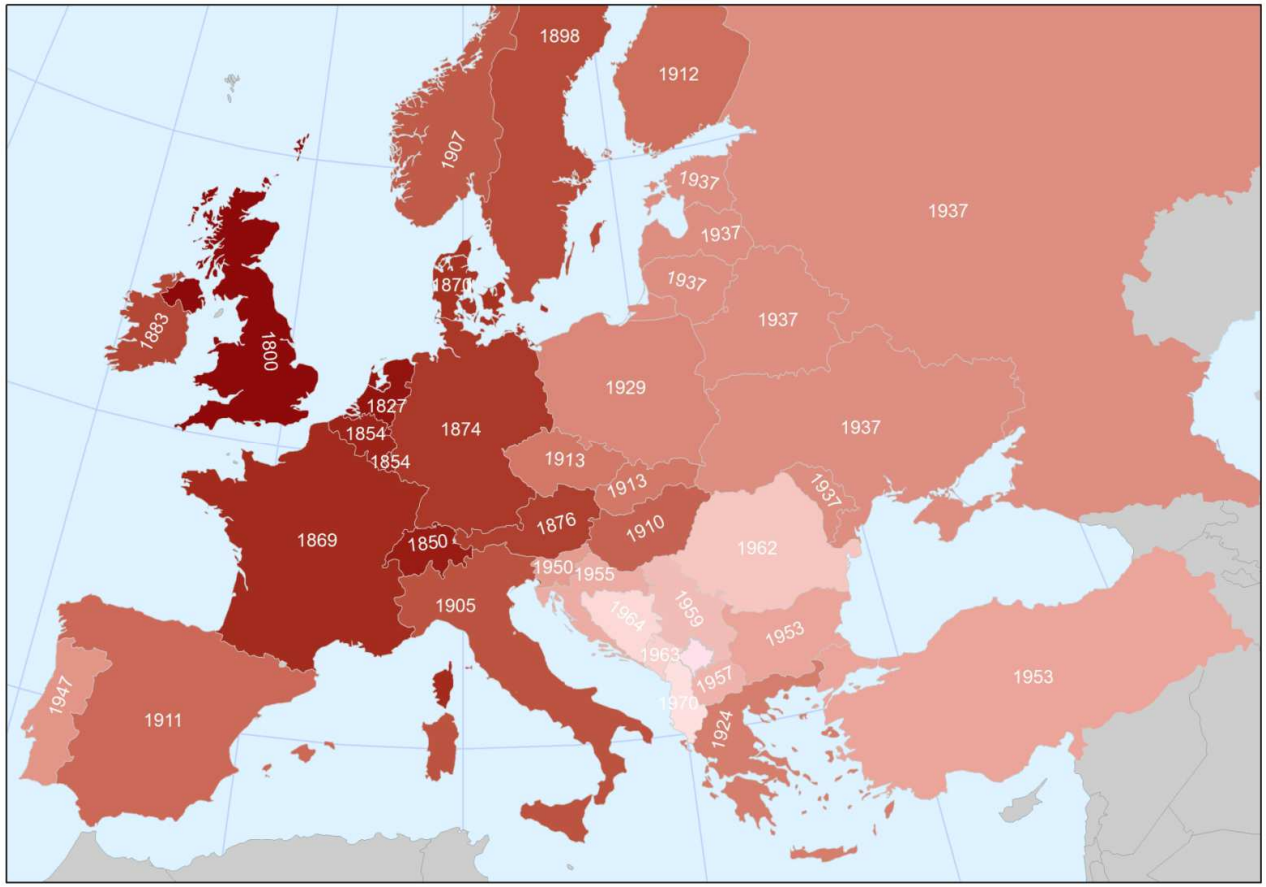
Railway Network Density in Europe 1870, 1910 and 2010



Source: HGISE (2015).

Year of Surpassing 2000 USD in GDP per capita



Note: Kosovo 2002 estimate based on wiiw data, CZ observation for Cezch and Slovan Republic; Belgian observation for Luxembourg, Soviet observation for Russia, Latvia, Lithuania, Belarus, Ukraine and Moldova.
Source: The Maddison-Project (2013), wiiw, own estimates.

Research Questions

Question at country level

'What is the impact of a higher railway mileage on economic growth, in particular for less developed (i.e. Southeast European) countries?'

Question at local level

'What are the direct and spillover effects of railway accessibility in Balkan cities?'

Data

- Maddison database
  - GDP per capita in real terms (in 1990 International Geary-Khamis dollar) covering European countries from 1830 to 2010 (unbalanced)
- Historical Geographical Information System for Europe (HGISE)
  - Country data per decade on railway infrastructure stock and country coverage covering European countries from 1830 to 2010 (balanced)
  - City data per decade on population (unbalanced), railway, geographical characteristics (both balanced) covering Balkan cities from 1850 to 2000
- To ensure comparability along the entire time span $\Rightarrow$ current country borders
  - In many cases territorial sub-divisions of historical empires with long-lasting institutions
  - The set of additional explanatory variables is restricted

Country Level Analysis

- Adressing the first research question
- Period of time: 1830-2010 in decades (unbalanced panel)
- Econometric Approach
  - Panel fixed effects regression model (baseline)

$$y_t = X_{t-10}\beta + D_t\theta + \mu_i + \eta_t + \epsilon_t \quad (1)$$

y_t ... real GDP per capita (annualised) growth rate ($n \times 1$)

X_{t-10} ... time-lagged explanatory variables ($n \times p$): (ihs-transformed) railway density, quartiles of GDP per capita

D_t ... institutional control dummies ($n \times h$): EU, Communism, Yugoslavia, Habsburg, Ottoman, Romanov Empire

μ_i, η_t ... fixed effects

ϵ_t ... error term

Country Level Analysis - Total Sample - Selected Results

Dependent variable:	*GDP per capita growth rate* $_t$			
	1830-2010			
	(1)	(2)	(3)	(4)
Railway density $_{t-10}$	0.360**	0.704***	0.245*	0.648***
	(0.157)	(0.152)	(0.133)	(0.195)
4^{th} *quartile of GDP per capita* $_{t-10}$	-0.495	-0.582	-0.307	-0.825
	(0.550)	(0.470)	(0.514)	(0.534)
3^{th} *quartile of GDP per capita* $_{t-10}$	0.202	0.0972	0.325	-0.284
	(0.370)	(0.338)	(0.339)	(0.410)
2^{th} *quartile of GDP per capita* $_{t-10}$	0.136	0.0417	0.171	-0.208
	(0.302)	(0.307)	(0.296)	(0.392)
Railway density $_{t-10}$ * *railway density* $_{t-10}$		-0.0858**		
		(0.0315)		
Railway density $_{t-10}$ * *Balkan*			0.540***	
			(0.135)	
Railway density $_{t-10}$ * 4^{th} *quartile of GDP per capita* $_{t-10}$				-0.508***
				(0.164)
Railway density $_{t-10}$ * 3^{th} *quartile of GDP per capita* $_{t-10}$				-0.226
				(0.150)
Railway density $_{t-10}$ * 2^{th} *quartile of GDP per capita* $_{t-10}$				-0.231
				(0.166)
Adjusted R^2	0.523	0.526	0.528	0.528
Countries	33	33	33	33
N	351	351	351	351

Country Level Analysis - Subsample - Selected Results

Dependent variable:	*GDP per capita growth rate* $_t$			
	1960-2010			
	(1)	(2)	(3)	(4)
Railway density $_{t-10}$	-0.327	9.050***	-4.508***	0.880
	(1.604)	(2.481)	(1.334)	(1.457)
4^{th} *quartile of GDP per capita* $_{t-10}$	-1.979**	-1.409**	-1.677**	-1.709**
	(0.816)	(0.680)	(0.642)	(0.693)
3^{th} *quartile of GDP per capita* $_{t-10}$	-1.576**	-1.227*	-1.427**	-1.792**
	(0.731)	(0.663)	(0.660)	(0.680)
2^{th} *quartile of GDP per capita* $_{t-10}$	-0.941	-0.894	-0.893*	-1.062
	(0.577)	(0.542)	(0.520)	(0.633)
Railway density $_{t-10}$ * *railway density* $_{t-10}$		-1.334***		
		(0.351)		
Railway density $_{t-10}$ * *Balkan*			6.640***	
			(1.640)	
Railway density $_{t-10}$ * 4^{th} *quartile of GDP per capita* $_{t-10}$				-4.294***
				(1.339)
Railway density $_{t-10}$ * 3^{th} *quartile of GDP per capita* $_{t-10}$				-3.164*
				(1.630)
Railway density $_{t-10}$ * 2^{th} *quartile of GDP per capita* $_{t-10}$				-1.606
				(1.045)
Adjusted R^2	0.517	0.542	0.553	0.535
Countries	33	33	33	33
N	171	171	171	171

City Level Analysis

- Addressing the research question at the local level
- No data on real GDP per capita at local level $\Rightarrow$ use population growth of cities as a proxy for regional economic development
- Period of time: 1850-2000 per decades for Balkan cities (unbalanced panel)
- Econometric Approach
  - Linear spatially augmented multilevel regression model (with random intercept)
  - Combining micro and macro level variables
  - Considering data structure (i.e. cities are clustered in countries)
  - Analysing the impact of railway accessibility of neighbouring cities (exogenous spatial lag)

City Level Analysis

$$y_{jk} = X_{jk}\beta + W_{jk}B\theta + \delta t + u_k + u_{jk} + \epsilon_{jk} \quad (2)$$

y_{jk} ... (annualised) population growth ($n_{jk} \times 1$)

X_{jk} ... explanatory variables ($n_{jk} \times l$): **micro**: time-lagged railway fractality, time-lagged population level, geographical measures, distance to capital city, origin of the capital used to build the railway tracks, railways hierarchy level; **macro**: conflict and crisis dummies, railway density, GDP per capita growth rate

B ... explanatory variable for spatial lag: time-lagged railway fractality ($B \subset X$)

W_{jk} refers to jk^{th} row of the row-standardized spatial weight matrix W ($N \times N$), where

$$w_{jk,s} = \begin{cases} 0 & \text{if jk} = \text{s } \forall \text{ jk,s} \\ \frac{1}{d_{jk,s}} & \text{if jk} \neq \text{s } \forall \text{ jk,s} \end{cases}$$

t ... trend; u_k, u_{jk} ... random effects; ϵ_{jk} ... error term

j cities nested in k countries, whereby there are $i = 1, \ldots, n_{jk}$ obs for each city over time

City Level Analysis - Selected Results with Spatial Lag

Dependent variable: *Population growth rate* $_t$				
			1850-2000	
		(A)	*(B)*	*(C)*
Micro:	*Fractality* $_{t-10}$	0.310	0.225	0.186
		(1.97)**	(2.28)**	(2.54)**
	Neighbours' fractality $_{t-10}$	3.402	2.152	1.503
		(2.11)**	(2.32)**	(2.33)**
	Population level $_{t-10}$	-0.238	-0.248	-0.254
		(4.94)***	(5.08)***	(5.19)***
	Distance to coast	-0.222	-0.230	-0.238
		(4.29)***	(4.43)***	(4.55)***
	Elevation	0.095	0.100	0.104
		(1.95)*	(2.04)**	(2.11)**
	Ruggedness	-0.073	-0.072	-0.073
		(2.37)**	(2.32)**	(2.37)**
	Funding from Austro-Hungary $_t$	-0.475	-0.489	-0.503
		(3.89)***	(4.01)***	(4.11)***
	Funding from France $_t$	-0.868	-0.886	-0.907
		(2.74)***	(2.78)***	(2.85)***
	Distance to capital city	-0.209	-0.206	-0.201
		(4.94)***	(4.86)***	(4.76)***
Macro:	*Railway density* $_{t-10}$	0.464	0.419	0.391
		(3.49)***	(3.05)***	(2.77)***
	GDP per capita growth rate $_{t-10}$	0.093	0.092	0.092
		(6.24)***	(6.22)***	(6.20)***
Countries		11	11	11
N		2,347	2,347	2,347

Conclusion

- Positive impact of railway infrastructure on GDP per capita growth for European countries
  - Higher for less developed European countries, particularly Balkan countries
  - Impact has changed during centuries
- Railway accessibility has positive direct as well as indirect effects on population growth of Balkan cities
  - Direct effects: agglomeration effects
  - Indirect effects: network effects and demand-driven externalities
    - Within as well as across countries
- Crucial role of (railway) transport infrastructure for economic development for Southeast European economies
  - Discussion on investments in infrastructure

References

Aghion, P., et al. (2013)

Investment in infrastructure

Investing in Propensity-Skills, infrastructure and innovation - Report of LSE p.22-27.

Aghion, P. and M. Schankerman (1990)

Competition, entry and social returns to infrastructure in transition economies

Economics of Transition 7(1), p. 79-101.

Ahlfeldt, G.M. and A. Feddersen (2015)

From periphery to core: measuring agglomeration effects using high-speed rail

SERC discussion papers No. 0172.

Atack, J., M., et al. (2008)

Railroads and the Rise of the Factory: Evidence for the United States

NBER Working Papers No. 15520.

References

Calderon C. and L. Serven (2014)

Infrastructure, Growth, and Inequality - An Overview

World Bank Policy Working Paper No. 7034.

Canning, D. and E. Bennathan (2000)

The Social Rate of Return on Infrastructure Investment

World Bank Policy Research Paper No. 2390.

Canning, D. and P. Pedroni (2008)

Infrastructure and long-run economic growth

The Manchester School 76(5), pp. 504-527.

Caruana-Galizia, P. and J. Marti-Henneberg (2013)

European regional railways and real income, 1870-1910: a preliminary report

Scandinavian Economic History Review 61(2), pp. 167-196.

References

Da Silveira, L. E., et al. (2011)

Population and railways in Portugal, 1801-1930

Journal of Interdisciplinary History 42(1), pp. 29-52.

Holzner, M., et al. (2015)

Infrastructure investment in the Western Balkans

wiiw Research Report No. 407.

Koopmans, C., et al. (2012)

An accessibility approach to railways and municipal population growth, 1840-1930

Journal of Transport Geography 2012(25), pp. 98-104.

Kotavaara, O., M., et al. (2014)

Role of Accessibility and Socio-Economic variables in Modelling Population Change at varying Scale

Journal of Geographic Information System 2014(6), pp. 386-403.

References

Rosenstein-Rodan, P.N. (1943)

Problems of Industrialisation of Eastern and South-Eastern Europe

Economic Journal 53(210-211), pp. 202-211.

Schwartz, R.M. (2011)

Spatial History: Railways, Uneven Development, and Population Change in France and Great Britain, 1850-1914

Journal of Interdisciplinary History 42(1), pp. 53-88.

Sugolov, P., et al. (2002)

Infrastructure Policies and Economic Development in East European Transition Countries: First Evidence

Paper for the Annual Conference of the International Society for New Institutional Economics September 2002.

Country Level Analysis - Subsample - Selected Results

Dependent variable:	*GDP per capita growth rate* $_t$			
	1830-1950			
	(1)	(2)	(3)	(4)
Railway density $_{t-10}$	0.303*	0.437***	0.290*	0.454**
	(0.146)	(0.148)	(0.145)	(0.181)
4th quartile of GDP per capita $_{t-10}$	-0.712	-0.791	-0.603	-0.758
	(0.908)	(0.869)	(0.903)	(0.819)
3th quartile of GDP per capita $_{t-10}$	0.186	0.0985	0.281	-0.156
	(0.541)	(0.512)	(0.530)	(0.469)
2th quartile of GDP per capita $_{t-10}$	0.134	0.0607	0.211	-0.117
	(0.385)	(0.364)	(0.366)	(0.255)
Railway density $_{t-10}$ * railway density t-10		-0.0371		
		(0.0223)		
Railway density $_{t-10}$ * *Balkan*			0.206*	
			(0.106)	
Railway density $_{t-10}$ * *4th quartile of GDP per capita* $_{t-10}$				-0.318**
				(0.114)
Railway density $_{t-10}$ * *3th quartile of GDP per capita* $_{t-10}$				-0.0701
				(0.0963)
Railway density $_{t-10}$ * *2th quartile of GDP per capita* $_{t-10}$				-0.123
				(0.122)
Adjusted R^2	0.355	0.354	0.354	0.356
Countries	21	21	21	21
N	180	180	180	180

City Level Analysis - Selected Results

Dependent variable: *Population growth rate* $_t$				
			1850-2000	
		(A)	*(B)*	*(C)*
Micro:	*Fractality* $_{t-10}$	0.348	0.264	0.223
		(2.25)**	(2.74)***	(3.14)***
	Population level $_{t-10}$	-0.236	-0.248	-0.254
		(4.94)***	(5.14)***	(5.26)***
	Distance to coast	-0.198	-0.203	-0.209
		(3.95)***	(4.04)***	(4.15)***
	Elevation	0.083	0.086	0.089
		(1.73)*	(1.79)*	(1.86)*
	Ruggedness	-0.071	-0.069	-0.069
		(2.31)**	(2.25)**	(2.28)**
	Funding from Austro-Hungary $_t$	-0.410	-0.423	-0.433
		(3.48)***	(3.58)***	(3.67)***
	Funding from France $_t$	-0.867	-0.89	-0.899
		(2.75)***	(2.82)***	(2.85)***
	Distance to capital city	-0.199	-0.195	-0.192
		(4.77)***	(4.67)***	(4.60)***
Macro:	*Railway density* $_{t-10}$	0.581	0.570	0.559
		(4.83)***	(4.72)***	(4.63)***
	GDP per capita growth rate $_{t-10}$	0.094	0.094	0.094
		(6.30)***	(6.30)***	(6.31)***
Countries		11	11	11
N		2,347	2,347	2,347