Railways and manufacturing productivity in Italy after Unification

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Abstract

This paper contributes to the debate on the effects of transport infrastructure endowment on productivity by adding a historical perspective. This allows us to address the issue in a proving ground where the effects of the existing stock of infrastructure are negligible. At the time of unification, the Kingdom of Italy initiated a large infrastructure project to build railways. We find that railways had a positive effect on manufacturing productivity over the period 1871-1911. Railways also had strong spillover effects in neighboring provinces so that provinces that started with a higher endowment of railways benefited more than those who were newly endowed.

Keywords: Railways, roads, manufacturing productivity, Italy.

* The scientific output expressed does not imply a policy position of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of this paper.

1. INTRODUCTION

The political unification of Italy in 1861 was followed by the policy decision to start a large infrastructure project based on railways. According to Schram (1997), its aims were both symbolic (pushing the newly born Kingdom into a modern endeavor) and practical (connecting places that have been historically separated and building a national market).

According to classical location theory, transport infrastructure endowment and investment lead to high returns. To this extent, greater accessibility and lower transportation costs facilitate trade and lead to a reduction in the price of traded goods, by enabling different territories to maximize their comparative advantage.

Putting the theory in our context, in this paper we analyze the effects of the policy endeavor of building an extensive rail network. We use economic history as a testbed for this analysis, taking advantage of the extremely low level of infrastructure at the time. This should provide clearer evidence with respect to contemporary analyses, in which the construction of new infrastructure is only marginally incremental vis-à-vis the existing stock.

Our main finding is that railways (and roads) played a crucial role in manufacturing productivity. This effect is statistically significant and economically sizable, with no discernible differences across the country, in particular along the North/South divide. We address the issue of possible endogeneity between railways and development, showing that our results can be interpreted as causal, running from railways to development.

The study of the relationship between infrastructure improvements and economic performance in a historical perspective started with Fogel (1964) and recently has been on the increase. In his seminal work, Fogel claimed that the level of per capita income achieved in the US by January 1, 1890, would have been reached by March 31, 1890 even without railroads, therefore maintaining that they had no effect.

More recently, for the US, Atack and Margo (2011) using GIS data, estimate that at least a quarter (and possibly two-thirds or more) of the increase in farmland in the 1850s can be linked directly to the coming of the railroad to the Midwest. Farmers responded to the reduction in transportation costs, which raised agricultural revenue, by expanding the area under cultivation. One-half or more of the growth in urbanization in the Midwest in the late pre-war period is attributed to the spread of the rail network (Atack et al. 2010). Donaldson and Hornbeck (2016) argue that as the railroad network expanded from 1870 to 1890, changes in market access were capitalized in county agricultural land values with an estimated elasticity of 1.1. Hornung (2015) finds a causal relationship running from railway construction to urban population growth in nineteenth-century Prussia. Surveying studies for England, Bogart (2014) maintains that transport improvements led to a growth in annual TFP of more than 2 percent from 1700 to 1870. Donaldson (2018) finds that in India railroads built by the British government decreased trade costs and interregional price gaps, increased interregional and international trade, and increased real income levels. In a recent survey, Atack (2018) claims that railroads were important to the economy and transformative in their effect but not decisive. By lowering transport costs – especially after adjusting for quality – they diverted trade and created new opportunities by generating positive externalities that promoted scale and agglomeration economies.

The paper is organized as follows: Section 2 reviews the history of railways in Italy and discusses some issues related to the North-South divide. In Section 3 we discuss the geographical dimension of our data. Section 4 introduces the modeling techniques, and the results are discussed in Section 5. Section 6 concludes.

2. THE HISTORICAL BACKGROUND

This section provides the historical background for our analysis. First, we give some insights into the history of railways in Italy in the period under consideration. Second, we briefly report some data and interpretations of regional differences in Italy, which are used subsequently for the interpretations of our findings.

2.1 A brief history of railways in Italy

Schram (1997) identifies four phases in the development of railways in Italy. The first took place from 1839 (when the first line was constructed) to 1865, when private foreign companies built the main lines under concession from the pre-unitary states (figure 1). Piedmont was an exception since the railway was built and managed by the state from the 1850s. The system of concessions differed between states and even within one state, leading to confusion and disparities between companies. After Unification in 1861, investments took off, with foreign investors willing to increase their involvement, given the plans of the new state, and its higher creditworthiness.

The second phase started in 1865 with the Railways Act, which reorganized railway companies into five franchisees. Piedmont State Railways were privatized due to the financial needs of the Kingdom, creating the Upper Italy Railway Company. The Act aimed to attract capital to expand the rail network by offering a high rate of return.

However, the returns were often negative, and companies were bailed out by the state. By 1878 – the beginning of the third phase - the government ran most of the tracks and operating companies. In 1885, a second Railway Act was passed, opting for a mixed system in which the tracks were state-owned, and the three operating companies were in the private sector. The last phase began with nationalization in 1905, following the poor performance of two railway companies.[i]

[Figure 1 about here]

The early literature on railways was concerned with the consequences of this infrastructure on growth. Romeo (1959) interpreted the resources devoted by the state to the construction of railways as a mechanism that, through taxation and government spending, redirected wealth from the relatively rich agriculture to the infant manufacturing sector. Investing in railways was a form of capital accumulation, fostering the take-off of the Italian economy in the following decades. The Marxist interpretation of Sereni (1966) claimed that railways fulfilled the aim of the bourgeoisie to create a single market, while its cost was borne by the working class. Both the liberal and the left-wing approaches emphasized the role of infrastructure, but differed in their evaluation of the burden of this investment.

Gerschenkron (1962) was the first scholar to call into doubt the positive effects of railways on economic growth. He maintained that the railway network was built too early for the industrialization of the country. During the first wave of investments in the 1880s, Italy needed imports due to the insufficient domestic supply of investment goods. The second wave of investments, after nationalization was too late to contribute to industrialization. Had the timing of investments in railways been different, the growth rate in the Giolittian age would have been higher.

Fenoaltea (1983, 2011) agrees that railways did not create a single market, but for completely different reasons. First, lines were subsidized by the state according to their actual length and not the crow-flies distance between two cities, incentivizing long and tortuous routes that failed to cut down journey times. Second, the fare structure was too costly for long-distance journeys. As a result, the railway network was used greatly below capacity, which in turn led to negative returns, underinvestment by private companies and subsequent nationalization.

State-ownership was also inefficient because it increased personnel in the absence of an increase in traffic.[ii]

Historical evidence indicates that politics was perhaps the major reason behind building the railway network. The first governments of the newly created kingdom needed a common endeavor for the country, and a massive investment was deemed to be a suitable venture. As a result, 4,000 km were built in the 1860s and a further 2,500 km in the 1870s compared to 2,000 km at the time of unification. The second spur to investments came when the Left took power, with 6,500 km built in the 1880s and up to the mid-1890s (Fenoaltea, 1983). Russel (1985: 42) claims that "the Italian 'railway boom' was not the driving force behind industrial development, which lay elsewhere" and adds that "the process of railway building was not closely related to the progress of industry in time or space", supporting the idea that political motives were behind railway construction.

2.2 The North-South divide

The literature on the economic dualism between the North and the South of Italy is well established and spans the past sixty years. A consensus has emerged over the last years, as summarized by Felice (2018). This maintains that at the time of unification there was a small income gap between the North and the South (about 10-15% in terms of manufacturing production per capita, but there were significant differences in terms of the pre-conditions of development, such as infrastructure endowment and human capital (Basile & Ciccarelli, 2018; Cappelli & Vasta, 2020).[iii] A mild divergence took place in 1871-1891 and increased in 1891-1911 when the Northwest started to take the lead and the South to lag behind.[iv]

Regional estimates of industrial production and of Gross Domestic Product (GDP) have become available only recently. Felice (2011, 2013) has provided a regional disaggregation of the new national-product estimates for some benchmark years in the 1871-1911 period. A long-term research project culminated with the publication of a large number of regional data series by Ciccarelli and Fenoaltea (2009, 2014).

Ciccarelli and Fenoaltea (2013) provide measures of industrial production for the 69 Italian provinces in the census years 1871, 1881, 1901 and 1911. This spatial disaggregation was obtained by allocating regional Value Added (VA) estimates to provinces using labor-force census data. The authors observe that the picture that emerges is multi-faceted. In the aftermath of Unification, the former capital cities were industrial leaders with a strong craft base, and a small area of the South, where some provinces benefited from freer foreign trade (the free-trade policy of the Kingdom of Piedmont was extended to the whole country) and infrastructure investment. However, this was a short-term effect: in the late nineteenth century, when the shift from crafts to industry was more marked, industry concentrated in the so-called 'industrial triangle' (Milan-Turin-Genoa). Ciccarelli and Fenoaltea (2013) conclude that the early twentieth century brought both industrial diffusion and concentration, the former in the center/north-east, where it was associated with the production of perishables on recently improved land, the latter within the north-western triangle. The shift was due to progress in energy transmission, which made the production of goods less tied to the waterfalls from which electricity was produced.

3. DATA AND THEIR GEOGRAPHICAL STRUCTURE

The data used in this empirical analysis are for 69 provinces and 4 benchmark years (1871, 1881, 1901 and 1911)[v] and were derived from both primary and secondary sources. For the dependent variable we rely on manufacturing Gross Value Added (GVA, calculated at 1911 prices) from Ciccarelli and Fenoaltea (2013) and on manufacturing employment from Ciccarelli and Missiaia (2013) that, to the best of our knowledge, are the most recent estimates.

Ciccarelli and Missiaia (2013) reconstruct the industrial labor force in post-Unification Italy based on population censuses of gender and four major components: mining, manufacturing (broken down into 12 sectors), construction, and utilities. The authors mention some caveats like the questionable representation of the labor force in the textile sector, which we have tried to overcome by not disaggregating manufacturing. The provincial area is from Ciccarelli and Fenoaltea (2013).

The variables from primary sources include the length of rail, from Ministero delle Comunicazioni, Ferrovie dello Stato (1927), the length of roads[vi] from L'Italia Economica (1873) and Annuario Statistico Italiano (1892, 1900 and 1912), and the literacy rate, from census results in 1871, 1881, 1901 and 1911 (Ministero di Agricoltura, Industria e Commercio, 1875, 1883, 1904, 1914). Appendix A details the rail (Table A1) and road (Table A2) endowment of each province.[vii]

While the data for roads are disaggregated by province, this is not the case for the Italian rail network. The Ministero delle Comunicazioni, Ferrovie dello Stato (1927) only gives the year of inauguration of each new rail line with start and end locations. To calculate the km of railroad network by province, we reconstructed the route of each line. The new dataset, available upon request, comprises the cumulative km of railroad network by province.[viii] Due to the importance of intra-regional and inter-regional trade in subnational development (Martin and Rogers, 1995), secondary lines with the same gauge as main lines were included and extra-urban tramway lines excluded.

Figure 2 shows the quintiles of the share of manufacturing GVA over employment in the first and last years of our analysis. Provinces in the North/North-East tend to upgrade in the distribution (becoming darker). However, provinces in the South fall down the development ladder in relative terms, as shown by their lighter colors.

[Figure 2 about here]

Figure 3 shows the quintile maps of the railways for each year. Railways appear rather concentrated in the north-west and the center-north of Italy in 1871, and this pattern is mostly confirmed in 1911.

Along with railways, there were also investments in roads. The Law on Public Works (March 20, 1865, no. 2248) classified roads in four categories according to their importance: national, provincial, municipal and local. Provincial and national roads changed their spatial patterns between the first and the second year considered. In 1871 they were concentrated in the center-north of Italy, while in the last year there was a lower concentration in the northern area.

[Figure 3 about here]

4. MODEL AND ESTIMATION TECHNIQUES

This section focuses on the relationship between infrastructure and provincial manufacturing productivity, taking into account the time dimension of the data.

Following Martin and Rogers (1995), public infrastructure can facilitate transactions inside the region (intra-regional trade attracting firms and contributing to convergence). However, if the infrastructure is financed by transfers that facilitate inter-regional trade rather than intra-regional trade, regional policy can have a detrimental effect on the poor region. Furthermore, it is conceivable that the "access to the roads and highways in other states [provinces] contributes to the effective stock of public-sector inputs, causing the effective stock to exceed the stock physically within the state's [province] borders" Holtz-Eakin and Schwartz (1995: 461). Therefore, in line with Holtz-Eakin and Schwartz (1995), Álvarez-Ayuso, Condeço-Melhorado, Gutiérrez, and Zofío (2016) and Rodriguez Pose, Psycharis, and Tselios

(2016), we also control for the effect of rail and road infrastructure in neighboring provinces to catch their spillover effects.

In addition to infrastructure endowment, we include a set of time-varying variables: agglomeration and literacy, as a proxy of education. According to Ciccone and Hall (1996), the former is fundamental for explaining the variation in productivity. The importance of agglomeration was raised by Marshall (1890), who claimed that intensive input-output linkages lead to a production advantage. Recently, the role of agglomeration and the channels through which it is transmitted have been widely investigated, with mixed findings. Melo, Graham, Levinson, and Aarabi (2017) find a strong positive effect of agglomeration on productivity, while the role of diseconomies related to agglomeration effects on economic outcomes are highlighted in Graham (2007) and Brülhart and Sbergami (2009). On the other hand, Artis, Miguelez and Moreno (2012) suggest that agglomeration is less important when variables related to knowledge and intangible assets in general are included in the regression. Following them, the variable accounting for literacy are included. Taxation is particularly important in our case. First, it provided the resources for investments in railways. Bignon, Esteves and Herranz-Loncán (2015) argue that a two-way relationship between government revenues and railways existed, with a potential for multiple equilibria. In particular, countries could end up in a "poverty-trap" with few railways and little revenue. Second, Italy has been struggling with its public finances since Unification, because of the cost of the wars undertaken to unify the country before 1861 - and to complete Unification in 1866 and 1870, public investments such as those analyzed here and the cost of building up a new state capacity, missing in most of the country (for long-run analyses of fiscal sustainability see Bartoletto, Chiarini & Marzano, 2014; Ricciuti, 2008).

Finally, we account for time-invariant variables that catch some features of the socio-economic (dummy south) and the geographical nature of Italian provinces (ruggedness index and distance from ports).[ix] Ruggedness accounts for the natural precondition favoring economic development. The distance from the main ports is a measure of the ease of reaching the main Italian commercial hubs. The number of *free cities* is a proxy for social capital.[x]

Our general empirical model is as follows:

$$Per\ employee\ productivity_{i,t} = \gamma_1 rail\ density_{i,t} + \gamma_2 rail\ density\ in\ neighbors_{i,t} + \gamma_3 road\ density_{i,t} + \gamma_4 road\ density\ in\ neighbors_{i,t} + \gamma_5 \ln\ literacy_{i,t} + \gamma_6 \ln\ population\ density_{i,t} + \gamma_7 south_i + \gamma_8\ south_i \times rail\ density_{i,t} + \gamma_9 ruggedness_i + \gamma_{10}\ inverse\ distance\ from\ ports_i + \gamma_{11} tax + \gamma_{12} free\ cities + \varepsilon_{i,t} \quad (1)$$

where the subscripts *i* and *t* denote, respectively, the province and the year and *ε* the idiosyncratic error term; *rail density* and *road density* are the share of the km of railways and provincial and national roads, respectively, over the provincial area in square km; *rail density in neighbors* and *road density in neighbors* are the average shares of these infrastructures in the border provinces; *literacy* is the logarithm of the percentage of people over 6 years old able to read and write; *population density* is the logarithm of the ratio between the provincial population and area in square km; *tax* is the logarithm of tax revenue per capita.[xi] Time-invariant variables include a dummy *south* referring to provinces in Southern Italy;[xii] *ruggedness*, an indicator of terrain ruggedness defined, following Nunn and Puga (2012), as the standard deviation of the provincial altimetry (data are defined at 30 arcseconds); and *inverse distance from ports* computed in km between provincial centroids and the nearest main port: Trieste, Venice, Leghorn, Naples, Messina, Palermo. To check for the possibility that by providing all provinces with an improved degree of accessibility lagging provinces are disadvantaged, as their firms are in a weaker position to compete than firms in the core, we introduced an interaction term between the dummy *south* and *rail density*; *free cities* is the number of cities, in each province, that were communes in the Middle Ages (Guiso, Sapienza & Zingales, 2016). Table 1 reports the summary statistics, and Appendix B provides a correlation matrix.

[Table 1 about here]

The estimation strategy is carried out in three steps. The first accounts only for variables in infrastructure; the second includes time-varying variables and the last step includes time-invariant variables.

Estimations in the first two steps are performed using standard and provincial fixed effects models, and the dynamic approach through a GMM, because these techniques do not admit time-invariant covariates. For the last step, as time-invariant covariates are included, standard and provincial random effect models and the Hausman-Taylor estimator (Hausman & Taylor, 1981) are used.

Although we claim that endogeneity may not be a serious issue because economic motives were unimportant in railroad construction (section 2), the Generalized methods of moments (GMM) and the Hausman-Taylor estimator are also used to deal with possible reverse causality which cannot be fully excluded. GMM with time-lags as instruments is used to deal with the potential endogeneity of infrastructure for example by Crescenzi, Di Cataldo and Rodriguez-Pose (2016). Although the system-GMM estimator (Blundell & Bond, 1998) is expected to be more efficient than any other dynamic GMM estimators, the validity of the additional instruments in system-GMM depends on the assumption that changes in the instrumental variables are uncorrelated with the fixed effects. In particular, they require that throughout the period, units sampled are not too far from steady states, in the sense that deviations from long-run means are not systematically related to fixed effects. This assumption is violated in a growing economy such the one we are analyzing here (Roodman, 2009).

However, the GMM estimator requires time-varying independent variables. When time-invariant variables are included, we rely on the Hausman and Taylor (1981) estimator. Based on an instrumental variable approach, this method uses the information for the instruments only from internal data transformations of the variables in the model, eliminating the correlation between the explanatory variables and unobserved individual effects. Furthermore, as noted by Mundlak (1978), no external information for model estimation is needed and no assumptions are needed about the correlation between the explanatory variables and the error components. In the Hausman-Taylor estimator, time-varying and invariant variables are classified in two subsets: uncorrelated and correlated with the unobserved individual effect. For the latter class of variables, the time-varying variables are instrumented by the deviations from their individual-specific means (within transformation), and the time-invariant variables are instrumented by the individual-specific means. The exogenous variables that are uncorrelated serve as their own instruments. The Hausman-Taylor estimator should produce estimations close to the fixed-effect estimator for time-varying variables. Thus, a Hausman test between the fixed-effects model and the Hausman-Taylor model enables the best specification to be chosen.

5. RESULTS

While with the random-effects estimation technique (table 2) both time-variant and invariant variables can be included, other methods have limitations. In particular, fixed-effects and GMM (tables 3 and 4) can only be implemented with time-varying variables, while the Hausman Taylor estimator (table 5) requires both time-varying and time-invariant variables, and at least one exogenous time-varying variable. To test the appropriateness of the Hausman-

Taylor model compared to the fixed-effect model, a Hausman specification test (Baltagi, Bresson & Pirotte, 2003) is applied. The significant p-value for the Hausman test in models 1 to 4 shows that fixed-effects estimation is adequate. In the remaining models, where additional regressors are included, a p-value > 0.05 is obtained and, consequently, the Hausman–Taylor model is preferred.

The coefficients of railway and road infrastructure are positive and highly significant in all the estimation techniques, with the exception of *road density* in all GMM estimates and rail density in some fixed-effects estimates. The coefficients of infrastructure densities in neighbors are more consistently positive and significant in all estimation methodologies. In addition, our results are in line with the findings of Álvarez-Ayuso et al. (2016) and Rodriguez Pose et al. (2016), i.e. infrastructure produces positive spillovers, confirming the hypothesis of Holtz-Eakin and Schwartz (1995).

As can be seen from the covariance matrix in Appendix B, some instabilities in the results might be due to multicollinearity, that increases the standard errors of the coefficients that, in turn, means that coefficients for some independent variables may not be significantly different from zero. In particular, the correlation between rail infrastructure, tax and population density is quite high. Rail density in the neighbors is highly correlated with road density in the neighbors, literacy and tax, and literacy with tax. A change of one standard deviation of railways has an impact between 1.27 and 4.59 times bigger than roads, depending on the estimates, showing that, other things being equal, railways have a stronger positive effect on manufacturing productivity throughout the country. The spillover effects have a similar impact for the two infrastructures but, if compared with their respective direct effects, the relative size of road spillovers is around four times larger, and the indirect effect of railroads is only 1.5 times.

In additional regressions, the geographical dummies are rarely significantly different from zero (tables 3 and 5), but results are very unstable, therefore the presence of a dichotomy *per se* due purely to geography. The interaction term between the dummy *south* and *rail density* is not significant, showing that railways in southern provinces do not have a different effect compared to other areas. *Ruggedness* is negative but not significant, showing that manufacturing productivity is not hampered by unfavorable natural conditions. Human capital, on the other hand, is strongly positive and significant. The sign and significance of our measure of agglomeration (*population density*) are positive and significant in all specifications except random-effect, where it is mostly not statistically different from zero.

[Table 2 about here]

[Table 3 about here]

[Table 4 about here]

[Table 5 about here]

The distance from the nearest main port is negative, as expected, but statistically not significant. The explanation may be related to the phases of Italian industrialization: initially, around 1870, production was essentially devoted to local consumption, so ports were not of much importance for trade (Ciccarelli & Fenoaltea, 2013). Subsequently, as production increased, the problem of distance between markets and from ports was overcome by improvements in the transport infrastructure, mainly railways. Appendix C shows the standardized coefficients of the infrastructure variables in some specifications of the estimation techniques we have applied. They clearly show that railways outperform roads.

Free cities – our measure of social capital - have a positive impact on manufacturing productivity in most of the Hausman-Taylor estimations, but this is not the case in the random-effects estimates.

Tax has a strongly significant and positive impact on productivity. We interpret this result as a consequence of a streamlined government budget, used mainly for basic public goods (with an emphasis on defense), interest payments on outstanding debt, and public works (Brosio, 2018). Therefore, government revenues were transformed into high-powered public investments that, coupled with their low initial values and therefore high marginal effects, positively affected production.

Finally, as a robustness check, not published for lack of space but available upon request, we test whether the contribution of transport infrastructure to productivity growth declines after a threshold due to the diminishing returns of continued infrastructure investments. For this purpose, we included the squared terms of road and rail infrastructures both together and once per time obtaining a non-significant coefficient of the squared term. This shows that in our case the transport infrastructure, being at its earliest stage of development, did not reach the threshold after which the benefits of additional transport investment tend to be nil or even negative.

6. CONCLUSIONS

This paper provides empirical evidence of the effects of railway construction in post-Unification Italy. Railways were rather concentrated in 1871, but not subsequently, when they become slightly more widespread in the peninsula. In contrast, there was a gap between the spatial pattern of manufacturing productivity in the northern and southern parts of the country and this grew over time. Our results show that public infrastructure, facilitating transactions within and between provinces, improved manufacturing productivity in all Italian provinces.

Railways served as a link between firms – located close to water and electricity plants - and the main markets and increased productivity. Moreover, the presence of a widespread network in the neighbors proved to be an effective stock of public-sector inputs (Holtz-Eakin

& Schwartz, 1995), also favoring manufacturing productivity. This means that an infrastructure network also has an indirect effect, extending its potentially positive effects to neighboring provinces. Moreover, the investment in railways was more important for productivity than the investment in roads.

Our results are somewhat in conflict with Gerschenkron (1962), Fenoaltea (1983, 2011) and Ciccarelli and Fenoaltea (2013) who claim a negative effect of railways on productivity (and growth, which is outside the scope of this paper). However, while making conjectures about the role of railways based on historical evidence, these studies do not carry out any statistical or econometric analysis. Our paper directly tests for the productivity effect by using a number of advanced techniques that make our claim causal.

This paper also conflicts slightly with two recent contributions claiming that the South was exploited by the North (more precisely by the Piedmont élite through conscription and heavy taxation (Brosio, 2018; de Oliveira & Guerriero, 2018).[xiii] Our results show the positive effects of the infrastructure policy on the country as a whole and specifically contradict de Oliveira and Guerriero, who maintain that railways did not shape the value added of the manufacturing sector, and hence industrialization. In contrast, our results are in line with Di Martino, Felice and Vasta (2020) who claim that industrialization policies were more effective in areas that showed some prerequisites (in our case an already existing rail network).

Further research may establish whether infrastructure had a role in productivity convergence/divergence across provinces, thus relating it more closely to the North-South debate. Moreover, it may be worth verifying the Gerschenkron hypothesis that railway investments were mistimed. This would involve the construction of a counterfactual GIS model to simulate the same investments in railways twenty years later.

Acknowledgments

We thank seminar participants at CNR-ISSM (Naples), IX IBEO workshop (University of Corse), Clare Hall College (University of Cambridge), the Italian Economic Society Conference and two reviewers for useful comments. The usual caveat applies.

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Table 1: descriptive statistics

Variables	Mean	Std. dev.	Min.	Max.
Ln of per employee productivity 1871	-7.523	0.350	-8.535	-6.796
Ln of per employee productivity 1881	-7.559	0.412	-8.782	-6.887
Ln of per employee productivity 1901	-7.110	0.260	-8.075	-6.664
Ln of per employee productivity 1911	-6.772	0.162	-7.378	-6.402
Rail density 1839-1871	0.025	0.023	0.000	0.132
Rail density 1839-1881	0.035	0.025	0.000	0.132
Rail density 1839-1901	0.059	0.036	0.000	0.269
Rail density 1839-1911	0.066	0.040	0.000	0.307
Rail density 1839-1871 in neighbors	0.025	0.013	0.000	0.068
Rail density 1839-1881 in neighbors	0.035	0.013	0.011	0.073
Rail density 1839-1901 in neighbors	0.058	0.015	0.024	0.108
Rail density 1839-1911 in neighbors	0.064	0.017	0.028	0.121
Road density 1871	0.127	0.067	0.043	0.455
Road density 1881	0.137	0.054	0.048	0.407
Road density 1901	0.172	0.055	0.068	0.426
Road density 1911	0.224	0.210	0.047	1.690
Road density 1871 in neighbors	0.124	0.039	0.059	0.289
Road density 1881 in neighbors	0.137	0.027	0.085	0.212
Road density 1901 in neighbors	0.168	0.029	0.105	0.262
Road density 1911 in neighbors	0.209	0.062	0.105	0.469
Ln of literacy 1871	-1.375	0.536	-2.323	-0.415
Ln of literacy 1881	-1.128	0.494	-1.995	-0.289
Ln of literacy 1901	-0.792	0.431	-1.570	-0.142
Ln of literacy 1911	-0.570	0.347	-1.224	-0.081
Ln of population density 1871	4.591	0.604	3.127	6.907
Ln of population density 1881	4.646	0.607	3.198	7.006
Ln of population density 1901	4.768	0.609	3.363	7.146
Ln of population density 1911	4.826	0.627	3.438	7.275
Ruggedness	325.505	195.839	2.841	941.933
Inverse distance from main ports	0.010	0.012	0.000	0.078
South	0.3623	0.4842	0.000	1.000
Ln of tax 1871	1.7006	0.3722	0.9544	2.5517
Ln of tax 1881	2.0827	0.3601	1.3457	3.1069
Ln of tax 1901	2.6577	0.4042	1.5719	3.7975
Ln of tax 1911	2.9091	0.4237	1.9061	4.0237
Free cities	1.9565	1.5857	0.000	7.000

Table 2: Random-effect estimates

Dep. Var.: ln of Per empl productivity	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
Intercept	−7.686	***	−6.9233	***	−8.1277	***	-8.4449	***	-7.7517	***	-6.7535	***	-7.0173	***	-6.9335	***	-6.8837	***
	(0.0856)		(0.3103)		(0.2778)		(0.1089)		(0.3364)		(0.2979)		(0.3046)		(0.3577)		(0.3609)	
Rail density	7.4800	***	1.8700	**	1.6275	***	1.4189	***	2.5575	***	0.4775		1.0866	*	1.0184	*	0.8172	
	(1.7834)		(0.5630)		(0.4895)		(0.5011)		(0.7686)		(0.5730)		(0.5907)		(0.6018)		(0.7332)	
Rail density			3.7178	***	5.3030	***	5.4768	***	8.6805	***			2.5638	*	2.7590	**	2.9521	**
in neigh.			(1.2634)		(1.1627)		(1.1397)		(1.0135)				(1.3270)		(1.2959)		(1.3780)	
Road density	0.6052	***	0.2147		0.2453	***	0.2418	***	0.2962	***	0.2163	***	0.1909	***	0.1877	***	0.1802	***
	(0.2147)		(0.0593)		(0.0819)		(0.0815)		(0.0805)		(0.0745)		(0.0538)		(0.0552)		(0.0501)	
Road density			2.2045	***	2.2329	***	2.2871	***	1.3045	***			1.9013	***	1.9240	***	1.8883	***
in neigh.			(0.3706)		(0.4116)		(0.4405)		(1.1290)				(0.3589)		(0.3673)		(0.3454)	
Literacy											0.5894	***	0.4469	***	0.4672	***	0.4634	***
											(0.1019)		(0.1124)		(0.1185)		(0.1192)	
Pop. density			0.4236	***					-0.1005		-0.0763		-0.0919		-0.0983		-0.0966	
			(0.0801)						(0.0694)		(0.0616)		(0.0621)		(0.0599)		(0.0597)	
Rail density*South			−0.1171	**	−0.0843				1.3045								0.4763	
			(0.0629)		(0.0551)				(1.1281)								(0.9790)	
South							-0.1307		-0.1986		0.0045		-0.0222		0.0180		-0.0155	
							(0.0986)		(0.1281)		(0.0782)		(0.0789)		(0.0880)		(0.1157)	
North-east							0.1211		0.1970	**	-0.1629	**	-0.0351		-0.0045		-0.0033	
							(0.0959)		(0.0985)		(0.0726)		(0.0791)		(0.0867)		(0.0904)	
North-west							-0.0282		-0.0063		-0.3174	***	-0.2007	**	-0.1700	*	-0.1841	**
							(0.0739)		(0.0889)		(0.0880)		(0.0847)		(0.0889)		(0.0875)	
Ruggedness									-0.0000						-0.0002		-0.0002	*
									(0.0001)						(0.0001)		(0.0001)	
Inv. dist. from ports									-4.3247	*							-3.5896	*
									(2.3148)								(2.0739)	
Tax					0.2223	***	0.1944	***			0.2085	***	0.0853		0.0659		0.0632	
					(0.0508)		(0.0497)				(0.0587)		(0.0526)		(0.0499)		(0.0483)	
Free cities					0.0250		0.0294		0.0381	*					0.0191		0.0192	
					(0.0162)		(0.0294)		(0.0205)						(0.0182)		(0.0191)	
Obs.	276		276		275		275		276		275		275		275		275	
sigma_u (individual)	0.0637		0.0455		0.0556		0.0456		0.0442		0.0402		0.0422		0.0405		0.0386	
sigma_e (idiosync.)	0.0761		0.0315		0.0351		0.0355		0.0356		0.0375		0.0315		0.0315		0.0317	
theta	0.5202		0.6158		0.6303		0.5429		0.5512		0.5646		0.6026		0.5955		0.5867	
AIC	327.241		104.583		153.402		148.203	***	148.352		85.981		86.447		82.549		78.406	

Notes: *** p<0.01, ** p<0.05, *<0.10. Cluster-robust estimate of the variance matrix (CRVE) performed following Wooldridge (2002, sec. 13.8.2).

Table 3: Fixed-effects estimates

Dep. Var.: ln of Per employee productivity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Rail density	10.5123 ***	1.6175 **	3.0773 ***	2.6640 ***	1.3497 *	1.2124	1.2367 *	1.0518	1.0891
	(1.7173)	(0.7974)	(0.6779)	(0.6300)	(0.7799)	(0.8603)	(0.7226)	(0.6539)	(0.8025)
Rail density in neighbors			7.6121 ***	7.7997 ***	2.2156	2.2734	1.7343		1.7739
			(1.1297)	(1.2197)	(1.4155)	(1.7094)	(1.6007)		(1.6556)
Road density	0.6718 **	0.2444 **	0.3147 ***	0.3116 ***	0.2123 *	0.2120 ***	0.2092 ***	0.2322 **	0.2086 ***
	(0.2984)	(0.0942)	(0.1093)	(0.1054)	(0.1165)	(0.0764)	(0.0786)	(0.0947)	(0.0777)
Road density in neigh.			3.1576 ***	3.1111 ***	2.4638 ***	2.4523 ***	2.4286 ***		2.4136 ***
			(0.5421)	(0.5420)	(0.3916)	(0.5115)	(0.5001)		(0.5129)
Rail density*South				0.7207		0.2369			0.2362
				(1.2295)		(1.1996)			(1.2005)
Literacy		0.6251 ***			0.3850 ***	0.3820 ***	0.3785 ***	0.5223 ***	0.3742 **
		(0.1002)			(0.0733)	(0.1271)	(0.1387)	(0.1295)	(0.1416)
Population density		0.6637 ***			0.3754 *	0.3847 *	0.3953 ***	0.4956 **	0.4015 **
		(0.2269)			(0.1967)	(0.1975)	(0.1996)	(0.2091)	(0.2011)
Tax							0.0274 *	0.1352 **	0.0302
							(0.0536)	(0.0674)	(0.0537)
Obs.	276	276	276	276	276	276	275	275	275
Hansen test random vs fixed eff. p -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
R^2	0.716	0.858	0.865	0.866	0.885	0.885	0.909	0.772	0.810
AIC	132.594	−55.294	−69.404	−67.969	−108.499	−106.566	-107.066	-61.051	-105.129

Notes: *** p<0.01, ** p<0.05, *<0.10. Cluster-robust estimate of the variance matrix (CRVE) performed following Wooldridge (2002, sec. 13.8.2).

Table 4: GMM estimates

Dep. Var.: ln of Per employee productivity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	8)	(9)
Intercept	−1.4733 ***	−2.9217 ***	−5.2538 ***	−4.9975 ***	−4.7251 ***	-4.7745 ***	-4.1033 ***	-4.7103 ***	-5.5550 ***
	(0.3618)	(0.3447)	(0.3360)	(0.3607)	(0.3990)	(0.3868)	(0.3697)	(0.3695)	(0.3146)
GVA/emp.$_{t-1}$	0.8127 ***	0.4215 ***	0.3906 ***	0.4224 ***	0.2980 ***	0.3166 ***	0.3930 ***	0.3111 ***	0.3791 ***
	(0.0439)	(0.0481)	(0.0394)	(0.0417)	(0.0442)	(0.0436)	(0.0426)	(0.0450)	(0.0377)
Rail density	6.1257 ***	3.9947 ***	2.6579 ***	2.2183 ***	3.3046 ***	2.4441 ***	1.4429 ***	0.6247	1.4775 ***
	(1.0123)	(0.7237)	(0.6105)	(0.69040)	(0.5223)	(0.5283)	(0.5447)	(0.6409)	(0.5482)
Rail density in neigh.			11.4321 ***	11.6930 ***	7.1523 ***	5.3903 ***		5.3469 ***	7.3528 ***
			(0.9832)	(1.1320)	(1.3386)	(1.3546)		(1.3905)	(1.3442)
Road density	0.1623	0.2743	0.0687	0.0548	0.0792	0.0603	0.1368	0.0246	0.0385
	(0.1819)	(0.2012)	(0.0707)	(0.0648)	(0.0966)	(0.0888)	(0.1441)	(0.0599)	(0.0683)
Road dens. in neigh.			1.5980 ***	1.4525 ***	1.7980 ***	1.4092 ***		1.0887 ***	1.2834 ***
			(0.3021)	(0.2935)	(0.3775)	(0.3800)		(0.3251)	(0.2812)
Rail density*South				0.7649				2.8453 ***	
				(0.6847)				(0.7854)	
Literacy		0.5200 ***			0.3291 ***	0.2526 ***	0.2473 ***	0.3506 ***	
		(0.0417)			(0.0605)	(0.0679)	(0.0593)	(0.0767)	
Population density		0.1959 ***			0.1670 ***	0.1939 ***	0.2382 ***	0.1887 ***	
		(0.0477)			(0.0407)	(0.0386)	(0.0408)	(0.0357)	
Tax						0.1710 **	0.4298 ***	0.2009 ***	0.2136 ***
						(0.0636)	(0.0592)	(0.0592)	(0.0525)
Obs.	276	276	276	276	276	275	275	275	275
AR(1) p -value	< 0.001	0.119	0.8216	0.8610	0.431	0.4362	0.3568	0.3277	0.9308
Hansen test p -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001

Notes: *** p<0.01, ** p<0.05, *<0.10. Asymptotic standard errors.

Table 5: Hausman-Taylor estimates

Dep. Var.: ln of Per empl productivity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-8.7072 ***	−8.2773 ***	-8.3701 ***	-8.2365 ***	-7.0065 ***	-8.2336 ***	-7.2935 ***	-7.3205 ***	-7.2829 ***
	(0.4308)	(0.2977)	(0.3568)	(0.3247)	(0.3811)	(0.3719)	(0.3293)	(0.3789)	(0.3909)
Rail density	2.0448 **	1.9681 ***	1.1656	2.8956 ***	1.1696 *	2.5128 ***	1.3781 **	1.3811 **	1.4996 **
	(0.7986)	(0.6084)	(0.7275)	(0.6658)	(0.6430)	(0.6680)	(0.6878)	(0.6881)	(0.7391)
Rail density in neigh.		5.3171 ***	5.3959 ***	5.9325 ***		8.0467 ***	2.9992 *	3.0336 **	2.9917 *
		(1.2337)	(1.2750)	(1.1009)		(1.2013)	(1.5673)	(1.5602)	(1.6611)
Road density	0.3414 **	0.2761 ***	0.2691 ***	0.3062 **	0.2127 **	0.3047 ***	0.1985 **	0.2012 **	0.2015 ***
	(0.1668)	(0.1068)	(0.1008)	(0.1040)	(0.8553)	(0.1021)	(0.0706)	(0.0725)	(0.0732)
Road density in neigh.		2.8323 ***	2.7283 ***	3.1652 ***		3.1200 ***	2.4034 ***	2.4086 ***	2.4181 ***
		(0.5351)	(0.5261)	(0.5470)		(0.5515)	(0.4785)	(0.4812)	(0.5013)
Literacy					0.5576 ***		0.3841 **	0.3807 **	0.3833 ***
					(0.1219)		(0.1359)	(0.1363)	(0.1396)
Pop. density	0.0180	-0.0515	-0.0317	-0.0311	-0.0334	-0.0181	-0.0612	-0.0660	-0.0623
	(0.0956)	(0.0607)	(0.0697)	(0.0721)	(0.0714)	(0.0792)	(0.0658)	(0.0647)	(0.0649)
Rail density*South			1.2460			0.6550			-0.1209
			(1.1720)			(1.2299)			(1.1705)
South				-0.1155	-0.0123	-0.1595	-0.0421	-0.0028	-0.0078
				(0.1029)	(0.0824)	(0.1355)	(0.0837)	(0.0914)	(0.1262)
North-east				0.2099 *	-0.1613 **	0.2073 **	-0.0029	0.0391	0.0397
				(0.0948)	(0.0763)	(0.1016)	(0.0857)	(0.0927)	(0.0968)
North-west				0.0120	-0.3208 ***	-0.0193	-0.1709	-0.1390	-0.1586
				(0.0812)	(0.0931)	(0.0922)	(0.0926)	(0.0968)	(0.0966)
Ruggedness	0.0003		-0.0001			-0.0000		-0.0001	-0.0001
	(0.0002)		(0.0002)			(0.0001)		(0.0001)	(0.0001)
Inv. dist. from ports	-2.0913		-2.5230			-4.5215 *			-3.8521 *
	(4.8503)		(4.3029)			(2.3611)			(2.1599)
Tax	0.4896 ***	0.1656 ***	0.1759		0.2064 ***		0.0640	0.0245	0.0628
	(0.0496)	(0.0525)	(0.0516)		(0.0717)		(0.0520)	(0.0193)	(0.0522)
Free cities	0.0094	0.0305 **	0.0363 **	0.0445 *		0.0449 **		0.0245 *	0.0236
	(0.0160)	(0.0174)	(0.0168)	(0.0223)		(0.0207)		(0.0193)	(0.0185)
Obs.	275	275	275	276	276	176	275	275	275
sigma_u (individual)	0.5323	0.3994	0.4102	0.4332	0.4054	0.4346	0.3690	0.3553	0.3529
sigma_e (idiosync.)	0.2112	0.1845	0.1837	0.1865	0.1912	0.1859	0.1745	0.1745	0.1745
theta	0.8639	0.8241	0.8330	0.8436	0.8181	0.8453	0.8171	0.8055	0.8034
Hausman test	36.47	4.96	10.65	7.73	7.35	14.26	5.58	5.74	5.65
HT estimator vs fixed effects	(p-val. < 0.001)	(p-val. = 0.292)	(p-val. = 0.031)	(p-val. = 0.102)	(p-val. = 0.118)	(p-val. = 0.006)	(p-val. = 0.233)	(p-val. = 0.219)	(p-val. = 0.227)

Notes: *** p<0.01, ** p<0.05, *<0.10. Cluster-robust estimate of the variance matrix (CRVE) performed following Wooldridge (2002, sec. 13.8.2). Endogenous variables in Hausman-Taylor estimator: rail density, rail density in neighbors, road density, road density in neighbors and tax.

Appendix A

Table A1: km of railways by province and census year, and sizes

Name	1871	1881	1901	1911	Area (sq. km)
Leghorn	22.726	22.726	22.726	27.345	345
Vicenza	54.497	87.065	109.445	183.324	2735
Verona	110.457	153.265	220.043	231.338	3071
Padua	72.295	160.347	198.294	232.614	2141
Catanzaro	0.000	114.820	192.789	192.789	5258
Cosenza	72.200	140.905	310.635	310.635	6653
Reggio Calabria	111.604	182.549	240.451	240.982	3164
Lecce	246.790	283.661	403.019	555.442	6797
Bari	118.090	118.090	220.279	322.101	5350
Potenza	64.480	217.181	405.262	405.262	9962
Parma	28.541	28.541	135.908	135.908	3238
Bologna	135.459	135.459	252.219	252.219	3752
Reggio Emilia	44.870	44.870	124.251	153.895	2291
Modena	44.870	79.256	186.377	203.297	2597
Ferrara	19.862	19.862	100.192	181.011	2621
Ravenna	62.396	62.396	170.037	170.037	1852
Brescia	110.339	120.524	226.504	326.501	4679
Turin	301.563	321.010	451.310	517.534	10236
Sondrio	0.000	0.000	66.579	66.579	3192
Salerno	55.430	94.870	169.695	202.602	4964
Foggia	144.048	144.048	228.968	228.968	6962
Venice	0.000	4.650	84.034	104.102	2420
Genoa	127.229	313.141	397.100	397.625	4099
Porto Maurizio	0.000	0.000	0.000	0.000	1179
Cuneo	128.400	213.416	398.643	405.852	7430
Alessandria	336.456	384.706	466.454	503.645	5088
Belluno	0.000	0.000	86.084	86.084	3349
Udine	95.439	193.410	329.489	360.980	6582
Treviso	58.834	108.634	170.674	182.074	2475
Massa Carrara	43.595	43.595	88.897	110.520	1781
Lucca	25.314	46.294	85.547	98.705	1445
Siena	152.787	231.585	239.007	239.007	3812
Grosseto	128.986	128.986	128.986	154.118	4502
Pisa	208.087	223.027	236.876	265.558	3055
Pesaro	46.477	46.477	104.843	104.843	2895
Forlì	47.132	47.132	68.363	68.363	1879
Arezzo	68.680	68.680	169.251	169.251	3298
Florence	248.565	248.565	342.295	342.295	5867
Ascoli Piceno	72.936	72.936	100.734	160.011	2063
Macerata	24.312	24.312	110.900	110.900	2816
Ancona	150.421	150.421	171.493	185.618	1938
Benevento	91.146	104.414	164.465	164.465	2118
Avellino	68.638	92.338	323.976	367.180	3037

Campobasso	51.436	51.436	270.633	281.355	4381
Naples	119.554	119.554	244.196	278.768	908
Caserta	76.775	76.775	76.775	76.775	5268
Rome	410.112	462.738	1009.600	1019.903	12081
Perugia	227.815	227.815	421.992	421.992	9709
L'Aquila	0.000	75.497	270.705	307.527	6436
Teramo	25.753	76.743	101.820	101.820	2765
Chieti	71.846	71.846	71.846	80.435	2947
Syracuse	57.800	79.802	328.882	328.882	3735
Catania	147.392	147.392	325.274	325.274	4966
Caltanissetta	0.000	80.682	87.712	87.712	3273
Palermo	103.025	243.355	356.939	395.410	5047
Girgenti	0.000	97.989	144.702	177.558	3035
Messina	47.070	47.070	190.395	190.395	3226
Trapani	0.000	122.230	122.230	146.101	2457
Pavia	220.799	220.799	275.899	277.9415	3336
Piacenza	50.406	50.406	50.406	84.386	2471
Novara	199.435	199.435	373.127	554.516	6613
Cremona	79.042	141.269	141.269	141.269	1756
Rovigo	28.090	81.132	92.212	92.212	1774
Mantua	12.853	42.963	110.798	121.186	2339
Milan	254.606	362.061	404.916	436.516	3163
Como	60.108	70.179	388.837	426.457	2861
Bergamo	77.840	77.840	106.655	143.710	2759
Cagliari	50.163	151.590	603.195	603.195	13431
Sassari	0.000	257.482	533.991	541.636	10678

Table A2: km of national and provincial roads by province and census year

Name	1871	1881	1901	1911
Leghorn	17	34.001	67.435	72
Vicenza	324.034	343.602	395.92	416
Verona	305.65	308.67	306.087	306
Padua	293.843	283.511	282.894	291
Catanzaro	327.891	446.339	770.632	1101
Cosenza	363.457	514.386	932.072	1151
Reggio Calabria	294.616	369.69	604.989	753
Lecce	633	666.431	1391.49	1627
Bari	550.002	687.369	923.971	999
Potenza	580.989	943.593	1606.769	1857
Parma	275.609	284.004	429.041	550
Bologna	402.965	413.788	539.475	557
Reggio Emilia	219.106	291.02	367.152	444
Modena	356.857	356.206	464.007	495
Ferrara	373	374.029	383.293	387
Ravenna	417	437.882	455.672	433
Brescia	568.792	578.3	641.874	649
Turin	786.343	803.763	1284.929	1259
Sondrio	214.799	203.827	218.83	218
Salerno	523.198	588.023	1011.777	1314
Foggia	441.749	613.518	737.453	1225
Venice	248.623	219.242	317.219	281
Genoa	652.788	616.042	659.534	891
Porto Maurizio	192.513	140.841	217.636	255
Cuneo	784.055	949.02	1325.86	1496
Alessandria	602.14	735.553	1030.639	1375
Belluno	234.81	161.64	272.916	310
Udine	387.273	452.207	485.526	509
Treviso	244.968	294.862	266.343	270
Massa Carrara	185.988	267.667	308.248	342
Lucca	289.225	311.55	326.01	**326**
Siena	696	708.938	766.645	842
Grosseto	547	538.127	546.473	583
Pisa	473	472.361	561.003	666
Pesaro	407.811	426.887	499.556	505
Forlì	433.54	439.971	487.303	489
Arezzo	508.707	497.186	565.1	571
Florence	1096.787	1168.53	1161.095	1220
Ascoli Piceno	429	494.231	518.302	622
Macerata	387.951	409.823	436.26	507
Ancona	344.79	334.138	381.717	412
Benevento	256.777	281.379	403.971	411
Avellino	533.155	598.062	857.036	1155
Campobasso	375.9	486.451	830.902	1279
Naples	333	369.214	386.861	466

Caserta	744.715	793.468	935.556	1011
Rome	1063.855	1169.956	1782.504	2282
Perugia	1331.998	1386.695	1675.004	1799
L'Aquila	359.081	550.846	880.634	1091
Teramo	205.759	305.338	507.018	651
Chieti	391.406	417.03	876.693	997
Syracuse	658.561	703.929	820.306	1172
Catania	413.758	574.108	763.135	1035
Caltanissetta	370.936	539.784	634.611	728
Palermo	509.327	733.85	767.646	921
Girgenti	350.262	307.974	424.02	499
Messina	274.671	337.487	485.954	494
Trapani	323.505	386.009	493.971	514
Pavia	609.965	751.202	801.719	801
Piacenza	226.778	298.396	320.172	322
Novara	706.301	764.785	987.458	1106
Cremona	231.348	328.569	386.636	391
Rovigo	174	215.772	215.772	235
Mantua	335.931	335.898	321.839	294
Milan	541.657	535.102	591.139	785
Como	390.998	400.271	487.986	551
Bergamo	476.246	490.454	517.958	511
Cagliari	789.555	1140.698	1616.439	1757
Sassari	674.125	1001.154	1130.273	1140

Appendix B

Correlation matrix

	Ln (GVA emp)	Rail density	Rail density in neigh.	Road density	Road density in neigh.	Literacy	Pop. Dens.	Rail density* South	South	North-east	North-west	Rugg.	Inv. dist. from ports	Tax	Free cities
ln(GVA emp)	1	0.3684	0.6219	0.2523	0.4821	0.7068	0.1301	-0.0177	-0.3665	0.112	0.1864	-0.0331	-0.0939	0.6854	0.1677
Rail density		1	0.2289	0.3956	0.2999	0.3964	0.5641	0.5601	-0.0435	-0.0479	0.0994	-0.2095	0.0706	0.5923	0.0718
Rail dens. in neigh.			1	0.2214	0.6067	0.6361	0.1734	-0.1062	-0.2362	-0.0307	0.3032	0.0624	-0.0240	0.6768	0.0188
Road density				1	0.2971	0.191	0.3601	0.2477	-0.0157	-0.1252	0.0759	-0.2197	-0.0469	0.3479	-0.0919
Road dens. in neigh.					1	0.3500	0.1919	0.1098	-0.0763	-0.1485	0.0323	-0.0599	0.0001	0.5359	-0.0232
Literacy						1	0.2838	-0.1997	-0.6544	0.2287	0.547	0.1875	-0.0179	0.7143	0.1645
Pop. density							1	0.2863	-0.1076	0.0453	0.2157	-0.2305	0.0389	0.3345	-0.1445
Rail density* South								1	0.6205	-0.236	-0.257	-0.0968	-0.0279	0.0957	-0.1884
South									1	-0.3803	-0.4142	-0.0674	-0.0548	-0.2979	-0.246
North-east										1	-0.2772	-0.0865	0.1091	0.0924	-0.1911
North-west											1	0.2733	-0.1176	0.2334	0.167
Ruggedness												1	-0.0486	-0.1392	0.0418
Inv. dist. from ports													1	-0.0597	-0.037
Tax														1	0.1922
Free cities															1

APPENDIX C

Table C1: standardized coefficients of the infrastructure

Dep. Var.: ln of Per employee productivity	Random effects, model (5)		Fixed effects, model (5)		GMM, model (4)		Hausman Taylor, model (6)	
Rail density	0.2051	***	0.1082	***	0.1451	***	0.2015	***
Rail density in neighbors	0.4233	***	0.1080	***	0.2928	***	0.3924	
Road density	0.0809		0.0580	***	0.0077		0.0832	***
Road density in neighbors	0.1544	***	0.2917	***	0.1952	***	0.3694	***
Obs.	276		275		276		276	

Notes: *** p<0.01, ** p<0.05, *<0.10. The standardized coefficients are calculated as the coefficient of a variable *i* multiplied by the ratio between the standard deviation of the variable *i* and the standard deviation of the dependent variable. The standard errors and the diagnostic statistics are the same as the respective tables from which the estimates are taken.

[i] This phase ended in the late 1990s, with EU-promoted liberalization, mainly in the cargo sector; a duopoly on high-speed lines was established in 2010.

[ii] Bogart (2010) applied a stochastic frontier methodology to estimate the inefficiency of state ownership in railways in 18 countries in 1880-1912. Italy was the least efficient in the 1900s. Inefficiency increased costs by 2.7% (against the average of 5.4%) in 1890-1899 and 7.3% (compared to the average of 5.8%) in 1900–1912. In a counterfactual estimation, the author claims that no more than 25% of state ownership would have brought about a 1.7% increase in efficiency.

[iii] Other aspects of the divide have been analyzed recently, for example: height (A'Hearn & Vecchi, 2017), market potential (Missiaia, 2019), innovation (Nuvolari & Vasta, 2017), and wages (Federico, Nuvolari, & Vasta, 2019).

[iv] Outside our period of interest, a significant gap opened up after the end of World War I until the "economic miracle" of the 1950s, when convergence took place until the 1980s, only to widen again, as now.

[v] In 1891 there was no census.

[vi] Data for roads are for 1872, 1880, 1897 and 1910, the closest available to the benchmark years.

[vii] For a history of roads see Badon (2011).

[viii] When the start and end locations are in different provinces, the length of the railway line in each province is calculated by overlapping the maps of rail lines with those showing the provincial boundaries.

[ix] Daniele, Malanima and Ostuni (2018) emphasize the role of geography and resource endowments in the development of Italian areas.

[x] An important stream of literature explains North-South differences in terms of the differing endowments of social capital. Social capital is unevenly distributed in Italy, higher in the North and lower in the South because of historic self-government in the North versus external domination in the South (Putnam, Leonardi & Nanetti, 1993) and strong preferences for the welfare of the family as opposed to the welfare of society (Banfield, 1958). Guiso, Sapienza, and Zingales (2011) restrict social capital to the set of values and beliefs that help cooperation, and use the term 'civic capital'. They argue that civic capital explains differences in economic performance and their persistence over centuries. Guiso Sapienza and Zingales (2016) test Putnam's hypothesis that the higher level of social capital in the North is due to the culture of independence fostered by the free city-states in the Middle Ages, claiming that 50% of the North-South divide is explained by historical differences in social capital. Cappelli (2017) and Ciccarelli and Stefano (2017) relate differences in social capital to industrialization.

[xi] Calculating taxation at the provincial level is a complex task, since data are partial and not continuously available, with the consequence that our measure is a proxy for overall taxation. Data include direct and indirect tax per inhabitant. Direct taxes include: business tax, internal trade taxes, tobacco tax, salt tax, milling tax (tassa sugli affari, dazi interni di consumo, tassa sui tabacchi, tassa sui sali, tassa sul macinato). Data for indirect taxes include land tax, building tax, income tax (imposta sui terreni, imposta sui fabbricati, imposta su ricchezze mobili). Data for 1871 are from Antonielli (1872), for 1881 and 1901 from Ministero di Agricoltura, Industria e Commercio (1900) and (1908), respectively, and for 1911 from Direzione Generale della Statistica e del Lavoro (1913). Data for 1871 refer to tax revenues for 1870, data for 1881 refer to tax revenues for the period 1871-1875, data for 1901 refer to tax revenues for the period 1898-1899 and data for 1911 refer to tax revenues for the period 1911-1912. The tax burden per inhabitant has been deflated using the deflator of indirect taxes by Baffigi (2013) at base year 1911, in line with the data on value added. Tax data for Rome are not available for the first period.

[xii] Provinces in the regions of Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicily and Sardinia belong to this area.

[xiii] Based on public works expenditure and the cost of administering justice, Gini (1914) claimed that the South received 35.8% of spending and contributed 32.0% to tax revenues, showing a positive fiscal residuum. This was possibly based on too narrow a definition of expenditure, but nonetheless highlighted the territorial redistribution through public works – and railways in particular – in the years after Unification, in exchange for the increase in taxation paid, in particular, by the South.